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ORIGINAL PAPERS

INTERFEROMETER MEASUREMENTS OF THE THERMAL DILATATION OF GLAZED WARE[1]

BY G. E. MERRITT and C. G. PETERS

ABSTRACT

The network of fine cracks often seen in the surface of glazed products not only mars the surface but shortens the life and lowers the price of the ware. Since the relative expansivity of the glaze and body is a very important factor in controlling this condition reliable measurements of both are of the utmost importance. Until recently the difficulty has been that the expansivity of the glaze has been measured on specimens of the material melted to glass and drawn into rods or cast in molds of sufficient length. Owing to the difference between this treatment and that received by the material when spread on the ware, it was realized that these methods might lead to unavoidable errors.

By the interference method, specimens 0.2 mm. in length can be measured with sufficient accuracy. Therefore in measuring glazes the samples may be taken directly from the finished ware. In this paper the thermal expansion of glaze materials prepared in the form of drawn glass or cast rods is compared with that of the same material taken from the finished ware. From the measurements, the expected divergence is found to be as much as 20% in the case of drawn glass specimens, and 10% for cast specimens.

I. Introduction

Glazed ware, which consists of a body such as terra cotta, white ware, porcelain, etc., covered with a thin layer of glazing material, very often cracks or crazes when subjected to temperature changes or even when allowed to stand for a period of time. The large percentage of

[1] Published by permission of the Director of the National Bureau of Standards of the U. S. Department of Commerce. Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Atlanta, Ga., Feb., 1926. (Terra Cotta Division). Received April 26, 1926.

such failures in glazed ware has been, and is still, a serious matter and is responsible for enormous losses to builders and other users as well as to the ceramic industry.

Cause of Crazing The crazing of a glaze doubtless results from the stresses set up by unequal expansion or contraction of the glaze and body. The capacity of a glaze to withstand these stresses depends upon its tensile strength, elasticity, thickness, and its adherence to the body. Being very brittle and in a layer only a few tenths of a millimeter thick, it cannot be expected to withstand large distorting forces. It follows that the most effective way to decrease the number of failures is to reduce the stresses below the yield point of the glaze. Stresses may arise from unequal expansion (or contraction) of the glaze and body caused by temperature change, by body absorption of moisture, by crystallization, or by compressive forces on the body. Dimensional changes of the body arising from crystallization which are sufficient to produce crazing are probably of rare occurrence. Material absorption of moisture by the body can only take place after the glaze has already cracked. The unequal thermal contraction of the glaze and body during the final cooling from the softening point of the glaze to room temperature is, in many cases, sufficient to produce forces capable of cracking or crushing the glaze. Hence, before more complicated causes of the failure are sought for, a close match in the thermal contractions of the glaze and body under the final cooling treatment over this entire temperature range must be attained, by the use of the right materials and treatment. This requires accurate data on the thermal expansions of both the glaze and body of the finished ware.

Measurement of Expansion Expansion measurements in previous investigations have been made with some form of micrometric apparatus which requires specimens 4 inches or more in length and at least $\frac{1}{4}$ inch in diameter. Since it is impossible to take samples of that size from the glaze of the finished ware the glaze batch material has been either melted to a glassy consistency in crucibles and drawn into long rods or cast in molds. It seems reasonable to suspect that the expansions of specimens made by either of these methods would not be the same as the expansion of the glaze on finished ware.

In firing, considerable interchange of constituents doubtless occurs between the thin layer of glaze and the body material, which makes the composition of the final glaze different from that of the cast or drawn specimens. Also the final heat treatment of the ware may be very different from that of the cast or drawn specimens thereby producing dissimilarities between their physical properties and those of the actual glaze. Tool and Eichlin[1] have shown that wide variations in some of the physical properties of glass can be produced by different heat treat-

[1] Tool and Eichlin, *Jour. Op. Soc. Amer. and Rev. Sci. Inst.*, **8**, 419 (1924).

ments even when no change in the composition of the material has taken place.

With the interferometric method described in Bureau of Standards, Scientific Papers, Nos. 393 and 485, the thermal expansion of specimens ranging in length from 0.2 to 10.0 mm. can be measured with sufficient accuracy in the temperature interval, 20 to 1000°C. Using this method in the present investigation, measurements were made on the expansivities of samples of the body and glaze taken from the finished ware and of cast and drawn specimens made from the same batch mixture as the glaze. This makes it possible to compare the expansivities of samples, made in the three different ways from the same glaze material, with each other and with the expansion of the body. These comparisons show that the expansion of the cast or drawn specimens may be very different from that of the glaze and that the specimens must be taken from the finished ware if reliable data is to be obtained. They also show that unless the expansivities of the glaze and body when subjected to the particular heat treatment used in making the ware, are nearly the same, stresses sufficient to produce crazing will arise.

Preparation of Samples

Six different batch mixtures of glaze material, the compositions of which are given in Table I, were prepared and specimens of each were made by the three following methods. These specimens will be referred to as: (1) drawn glass, (2) cast, and (3) glaze, specimens.

(1) Drawn Glass Specimen The glaze batch material was fed into a porcelain crucible heated in a gas-fired furnace until a clear melt was obtained. An iron bar or pincers was then thrust into the pot and a rod of the glass drawn out. Three sections, each about five millimeters long, cut from this rod, constituted the specimen.

(2) Cast Specimen Glaze material was piled on a V-shaped groove in the upper face of a porcelain block and fired in a kiln to the temperature at which the glaze was supposed to mature. Three fragments broken from this cast were used for the specimen.

(3) Glaze Specimen Plates of ordinary table whiteware or blocks of terra cotta were first glazed with the material. The type of bodies chosen and the technique employed duplicated common commercial practice. A sample of the glaze 0.2 to 0.4 mm. thick was broken from the surface of the finished ware and freed from any adhering fragments of body. A microscopic examination insured removal of the undissolved body. Three fragments of the resulting flake of glaze were used for a specimen.

Table I

	A	*B*	*C*	*D*	*E*	*F*
SiO_2	54.6	52.0	49.7	47.4	60.5	52.0
Al_2O_3	8.7	8.5	12.7	9.2	14.9	9.1
CaO	8.6	7.9	7.0	9.6	10.4	7.0
PbO	16.3	15.6		15.6	11.3	16.0
ZnO	3.6	4.1	3.4	5.4	2.9	3.2
SnO_2	0.2	0.1		0.2		0.2
K_2O	0.7	2.4	9.7	0.3		0.1
Na_2O	0.7	2.4		3.6		3.4
B_2O_3	6.6	7.0		8.7		9.0
MgO			1.7			
BaO			15.8			

Experimental Method of Procedure

In each case the prepared specimen was placed between two fused quartz interferometer plates and heated in an electric furnace at the rate of 2.5° per minute to some temperature above the annealing range of the glaze. The heating current was then cut off and the sample allowed to cool in the furnace. The rate of cooling at the start was about 5° per minute. During both heating and cooling, the temperatures and the changes ΔL in the length, L, of the sample were recorded as the interference fringes passed a reference mark on the upper plate.[1] The first run was followed by a second taken over the same temperature range and using the same heating and cooling schedule.

Since the strains that crack the glaze are set up during the final cooling of the finished ware, it is essential to have the expansivities of the glaze and body match during that process. We have found from repeated runs on various materials that the expansion of any particular heating is usually very similar to the contraction of the cooling immediately preceding and supplies more information regarding the effects of that cooling treatment than any subsequent heating or cooling data. From this it follows that the first heating curve furnishes valuable information about the way the samples contracted when cooled during the process of manufacture. The second runs give the expansivities of the samples after they had all received practically the same heat treatment as a result of the first runs. The differences in the first run expansivities may be caused by differences in the composition and the final heat treatment, resulting from dissimilarities of the three methods of producing specimens from a given glaze material. The

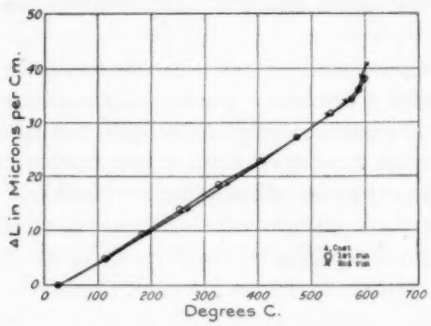

FIG. 1.

[1] See Bur. Stand., *Sci. Paper*, No. 393 for a description of the apparatus.

second run, however, is taken after the specimens have all received nearly the same heat treatment as a result of the first runs, hence any differences in the expansions of the specimens prepared by the three methods must be ascribed to differences in composition or molecular arrangement.

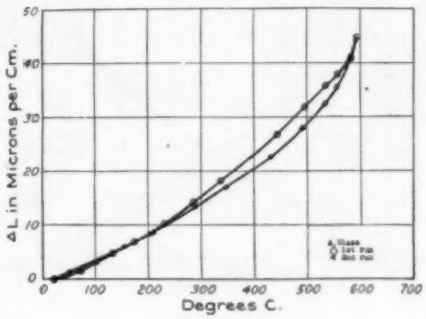

FIG. 2.

These changes in composition may be caused by the volatilization of certain constituents, by the absorption of impurities from the body or by contamination by furnace gases. The possible differences in the combinations between the constituents may be modified by such changes in composition or by the temperature and time required in the production of the sample.

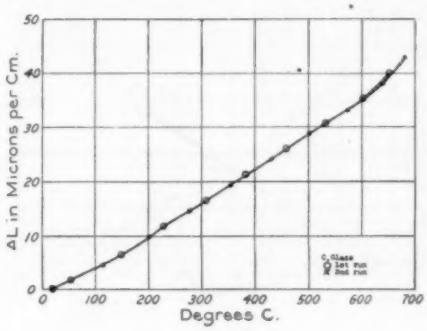

FIG. 3.

Experimental Results

Figures 1 to 7 inclusive show measurements obtained by first and second runs on several samples. In some cases the expansion during the second heating was nearly the same as during the first, while in other cases the expansivity was changed considerably by the treatment received during the first run. With glaze material *A*, the curves from the two runs on a cast sample, Fig. 1, are nearly the same while those for the glaze sample, Fig. 2, are different. In the case of glaze material *C*, the reverse is true. The results from the two runs on the *glaze* sample, Fig. 3, are almost identical while those for the *cast* specimen, Fig. 4, are very different. The curves representing the results from the first and second runs on the cast specimen, Fig. 5, from glaze material *D*, agree very well; while those for the drawn sample, Fig. 6, diverge at

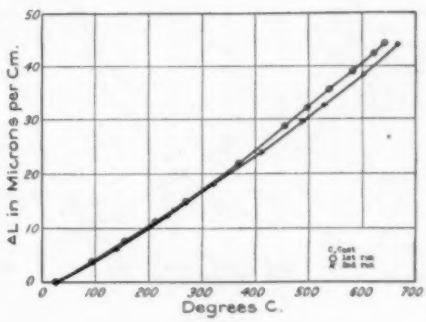

FIG. 4.

about 400°C. The rod from which the drawn sample was taken must have been cooled quickly when drawn from the pot, otherwise the drop in the expansivity above 500° similar to that shown by chilled glasses could not be accounted for. The curve representing the second run shows the effect of the annealing treatment received during the first run. Data obtained from the first run on samples of this kind would be of little value in matching expansivities of glazes and bodies.

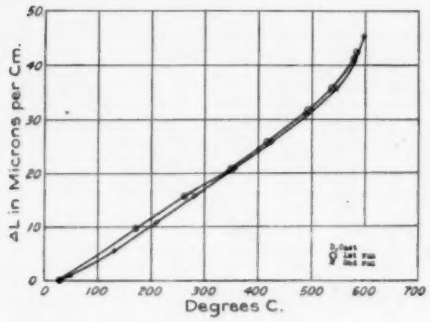

FIG. 5.

The two curves shown in Fig. 7 represent the results from the first and second runs on a sample taken from the body that was used with glaze *D*. The expansion of the first run shows a large decrease between 100 and 300°C and a rapid increase in the α–β quartz transformation region. In the second run, the expansion did not decrease in the lower region, but increased as before near 575°C. These two curves are typical of results we have obtained from first and second runs on a large number of body materials and suggest that the peculiar expansivity of the body may be responsible for some of the difficulty in matching glazes and bodies.

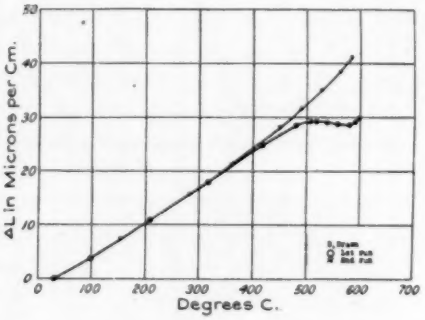

FIG. 6.

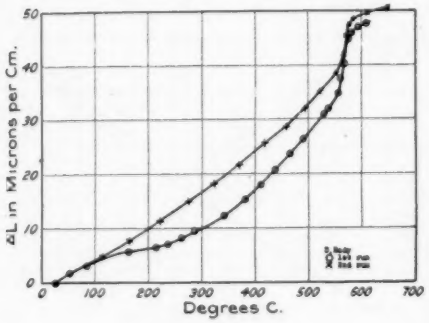

FIG. 7.

In the ten figures, 8 to 17 inclusive, are two for each glaze batch mixture, one of which represents the results from the first runs on specimens prepared by the three methods and the other, the second runs on the same specimens. If either a cast or a drawn specimen is to give the correct thermal expansion of the glaze, the result from the first run must

agree with that of the first run on a glaze sample taken from the finished ware. In case there is a disagreement, the dissimilarity may be caused by differences in the previous heat treatment, the composition or the molecular arrangement, all of these differences being produced by the manufacturing process used.

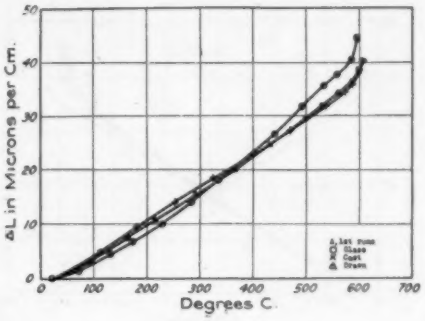

FIG. 8.

The same heating and cooling schedule was maintained during the first run for all the samples from a given batch. The rate of heating and cooling was low enough so that any effects of sudden cooling during the process of manufacture should be removed, thus leaving the samples in a fairly well annealed condition.

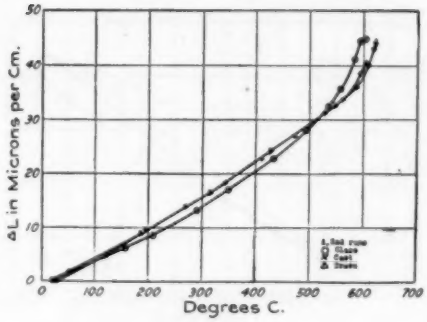

FIG. 9.

The figures representing the second runs are included to show the expansion of the samples made by the three different methods after they had all received the same annealing treatment. Since, as stated, the first run largely eliminates the differences arising from heat treatment, any difference in the second run expansions of the samples made by the three methods from a given batch mixture, indicates a difference in the composition or molecular arrangements of the three types of specimens. If such differences in composition are found, the inadvisability of using results from cast or drawn specimens to represent the expansivity of the glaze becomes evident.

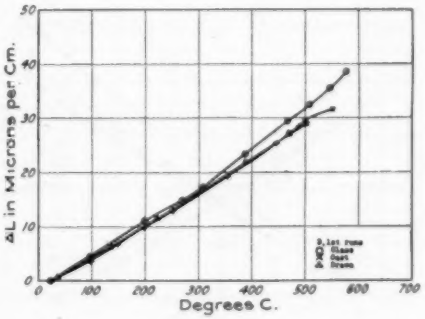

FIG. 10.

The first runs on the three types of specimens from batch mixture *A*, Fig. 8, show that the expansions of the cast and drawn specimens are nearly the same and

that both differ considerably from the expansion of the glaze. The second runs on *A*, Fig. 9, show even a better agreement between the expansions of the cast and drawn samples. The shape of expansion curve and amount of expansion from 20 to 600°C are, however, very different for the glaze from what they are for either the cast or drawn specimens.

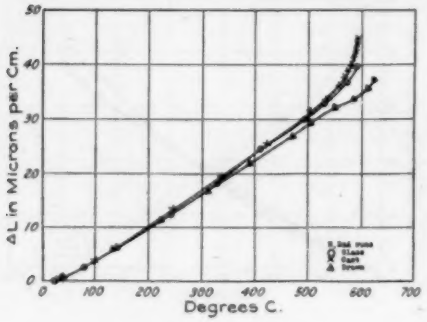

FIG. 11.

The expansions of the first runs on the cast and drawn specimens from batch mixture *B*, Fig. 10, are similar and both differ from the expansion of the glaze. The second run of the glaze and cast samples of *B*, Fig. 11, are nearly alike, but the cast one shows a lower annealing temperature. The drop between 550 and 600°C in the curve from the drawn specimen shows that the effects of chilling had not been entirely removed by heating to 500° during the first run.

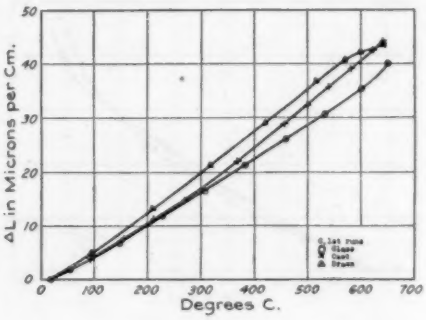

FIG. 12.

With batch mixture *C*, Figs. 12 and 13, the heat treatment given in preparation produced an effect tending to neutralize the effect of change of composition, so that the curves for the second run diverge from each other more than those of the first. Note that the cast and drawn specimens differ from each other as well as from the glaze both in the first and second runs. This may be ascribed to greater loss of volatile constituents and to other changes due to heat in the case of the drawn specimen, since it was necessarily heated to a higher temperature than the cast. A difference in the expansivities of a body and its glaze comparable with the differences

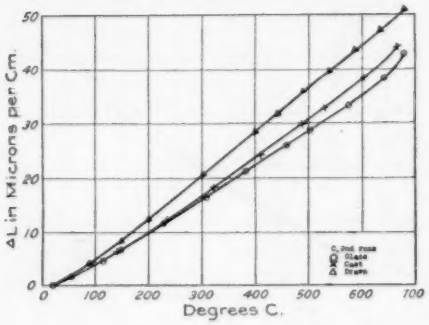

FIG. 13.

exhibited by these specimens would doubtless cause crazing. For batch mixture *D*, Figs. 14 and 15, the expansion of the glaze and cast specimens show about the same divergency for both the first and second runs. This may indicate that their original heat treatments were similar, but that the composition of the glaze was very different from that of the cast specimen. The expansion of the drawn specimen decreased rapidly between 500 and 600°C during the first run showing the specimen was badly chilled. For determining the expansivity of a glaze, data from the first run on a chilled sample like this are worthless, since glazes are almost always annealed to a much greater degree. They are only valuable for showing the poorly annealed condition of the drawn specimen.

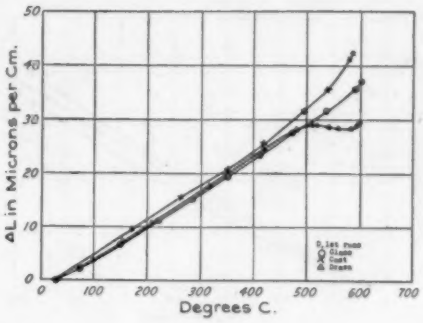

FIG. 14.

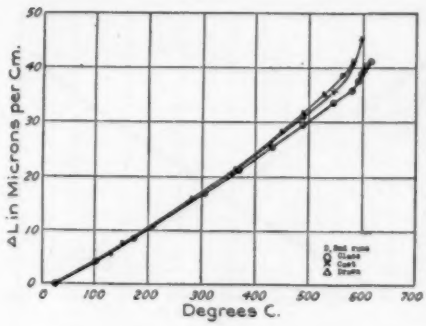

FIG. 15

The results from the first runs on the three samples of batch mixture *E*, Fig. 16, agree reasonably well. The poor agreement of the results from the second run, Fig. 17, show, however, that the similarity of the first runs were only a chance effect of heat treatment. A difference in composition or character of the glaze and cast and drawn specimen is evident.

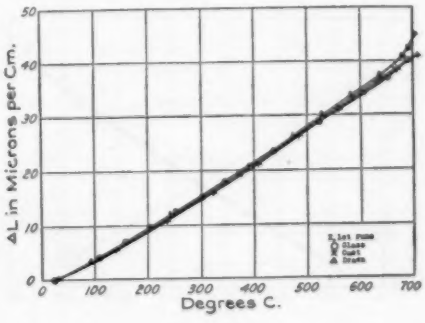

FIG. 16.

Discussion

The data presented thus far show that the thermal expansion of a given sample is affected by its previous heat treatment and that its final composition and molecular arrangement depend upon the method of production. From this it is evident that drawn specimens which, as a rule, are chilled, should not be used under

any circumstance and that even the second run on the glaze sample should not be taken as representing the expansion of the glaze on the finished ware. The results from the second runs on each batch mixture show that the composition and molecular arrangement of glaze is different from either the cast or drawn specimen. This makes the use of either of the two latter types an unsafe procedure.

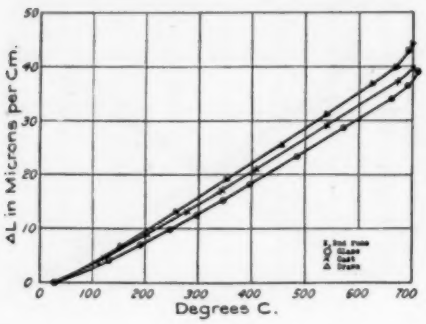

FIG. 17.

Check on Methods

To show that the inconsistencies in the expansions in these different types of samples made from a given batch mixture were not caused by errors in the method of measurement or lack of homogeneity in the glaze, measurements were made on samples of glaze taken from different parts of the same brick. The crosses and circles, Fig. 18, represent the expansions during the first runs on two separate samples, both taken from the surface of a brick that had been glazed with batch mixture *C*. The second runs on the same two samples are shown in Fig. 19. The agreement between the two samples is very good in both cases. The first and second runs agree with each other showing that the brick had been cooled slowly. Measurements taken in the same way on two samples from a brick glazed with batch mixture *E*, are shown in Figs. 20 and 21. Here the agreement between the first runs on the two samples is excellent. The second runs are nearly the same. The first runs, however, differ somewhat from the second indicating that this brick must have cooled more rapidly than *C*.

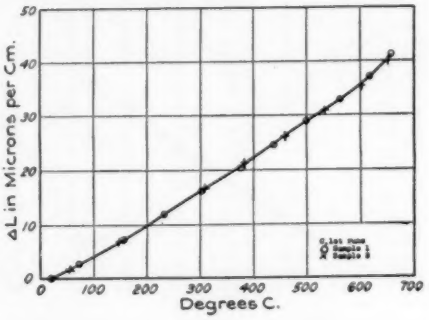

FIG. 18.

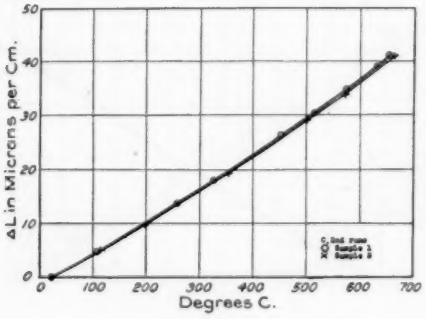

FIG. 19.

Expansion Normal vs. Parallel to Surface

Owing to the thinness of the glaze taken from the finished ware, the three pieces forming the specimens were broken from a flake and the expansivity was measured in the direction normal to the surface of the glaze. Since it is the expansivity parallel to the surface of the glaze that must match the expansion of the body, the objection might be raised that the measurements made normal to the surface do not represent the expansion of the glaze. Measurements were, therefore, made in both directions on samples from a brick glazed with batch mixture *E*. For the first run, Fig. 22, the expansion perpendicular to the glaze surface is represented by circles and that parallel to the surface by crosses. The second runs on the same two samples are shown in Fig. 23. From the close agreement of these results, it appears that no directional difference in the expansion of the glaze exists.

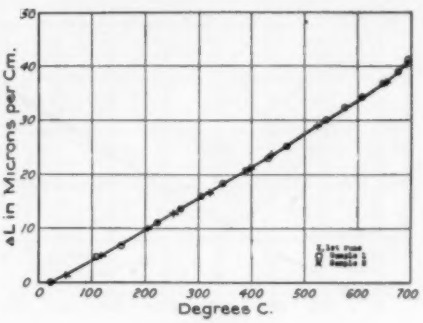

FIG. 20.

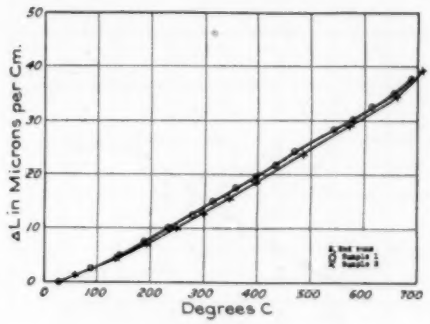

FIG. 21.

What appears to be a still more drastic test was made by using the samples from drawn rods. These were selected because of their rapid and unsymmetrical cooling which made it seem probable that these specimens, if any, would show a directional difference in expansion. Figure 24 gives the results of two first runs on samples from the same drawn rod, the crosses representing measurements parallel to the axis of the rod and the circles, those taken radially. Figure 25 shows results

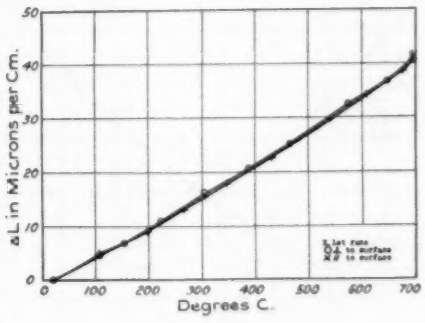

FIG. 22.

of the second runs on the same samples. It will be noticed that although results of the first and second runs are very different, the first runs on the two samples agree closely with each other and the second runs on the same samples show equally good agreement.

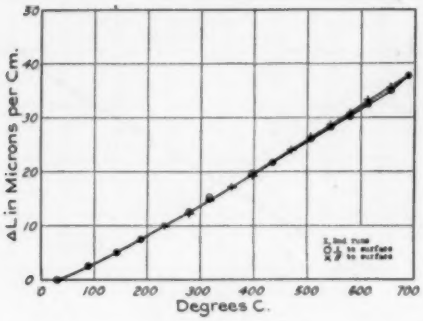

FIG. 23.

The Figs. 26 to 32 inclusive, show comparisons between the expansions of cast and glaze samples of batch mixtures, *A*, *D*, and *F* along with the expansions of bodies from which these glaze samples were taken. The results from first runs are used in each case because, as previously stated, they represent the best obtainable values of the contractions during the preceding cooling. The curves for the glaze and body are brought together in the annealing range of the glaze and from that point to room temperature they should represent closely the contraction of the glaze and body during the final cooling of the ware. The temperature where the curves should be made to coincide is of course, the one where, under a given cooling rate the glaze becomes more or less rigid, thus starting the accumulation of stresses. To determine this temperature and successfully interpret the expansion curves requires knowledge of several of the physical properties of the glaze, exact data on the cooling schedule of the ware and considerable experience in making thermal expansion measurements.

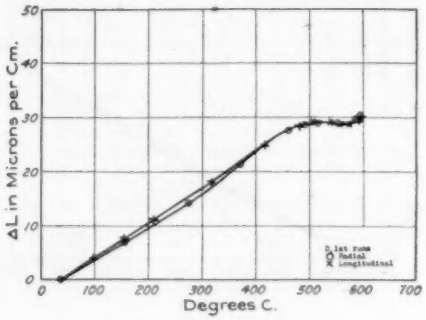

FIG. 24.

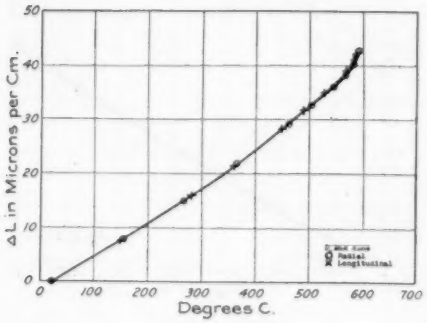

FIG. 25.

Temperature at Which Stresses Start to Accumulate

In a previous paper on the thermal dilatation of glass[1] the relation

[1] Peters and Cragoe, Bur. Stand. *Sci. Paper*, No. 393, pp. 476–80.

between the deformation from constant pressure and expansivity is given for several glasses at high temperatures. We have continued this work on glaze and other glasses during the past few years and our results show that all glasses exhibit comparable characteristics. From room temperature to the critical region, which is usually located somewhere in the range from 450 to 600°C depending on the composition of the material, the glasses expand at a nearly uniform rate and appear to be very rigid. Through a critical region of approximately 75° the glasses or glazes expand rapidly and soften at a rate that accelerates with the rise in temperature. Above the critical region the rate of expansion appears to become about the same as it was in the lower interval and the softening continues to increase rapidly. The annealing range is usually considered to include the lower half of the critical region and to extend somewhat below it.

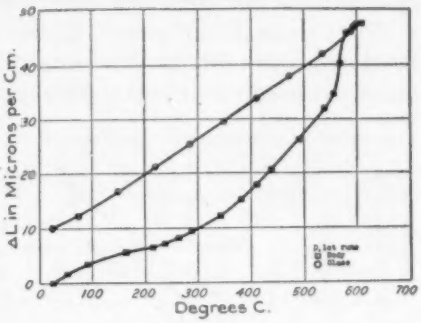

FIG. 26.

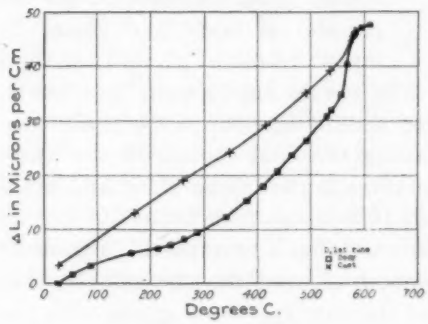

FIG. 27.

The glass samples and quartz plates fuse together at temperatures above the critical region. With the glass in the form of a solid ring, a large differential expansion exists between it and the plate because of the low expansivity of the quartz. On cooling through the critical region, it is found that on reaching the upper end of the annealing range, the glass becomes rigid enough to produce forces sufficient to bend the quartz plates as indicated by a change in the shape of the fringes. The plates continue to bend until the temperature falls to about the lowest limit of the annealing range

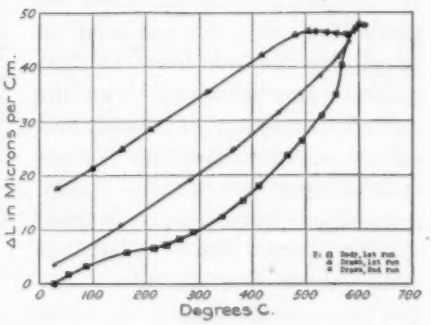

FIG. 28.

or to a point just below the bend in the expansion curve, when a rupture of either the plates or ring takes place.

From these observations it can be estimated with reasonable certainty that the temperature at which stresses start to accumulate in a glaze, in case it contracts differently than the body, is about 20° above the beginning of the critical region or near the upper limit of the annealing range; and furthermore that a differential contraction of about 5 microns to the cm. is sufficient to produce cracks in the glaze.

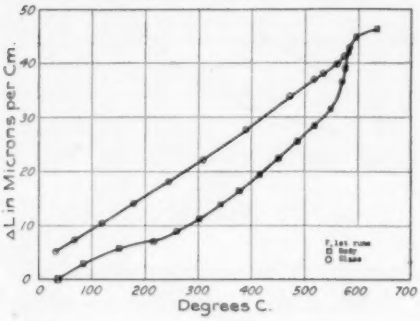

FIG. 29.

Effect of Difference in Expansion of Body and Glaze

The first run expansion of samples of body and glaze, *D*, taken from a plate that had crazed badly is shown in Fig. 26. The curves are brought together in the annealing range of the glaze and should represent closely the contractions of the glaze and body during the final cooling of the ware. These data show dimensional differences between the glaze and body of 17 microns per cm. at 350°C and 10 microns per cm. at 20°, which is ample explanation for the crazed condition of the plate. Figure 27 shows a comparison between the same body and the cast sample from batch mixture *D*. The expansion of the cast specimen agrees with the body expansion much better than does that of the glaze, especially at room temperature. An attempt to compare the expansions of the body and drawn specimen of batch *D* is made in Fig. 28. The results from the first run show the chilled condition of the drawn sample and demonstrate the unreliability of conclusions drawn from data obtained from that kind of specimen. Even the results from the second run do not agree with those from the glaze.

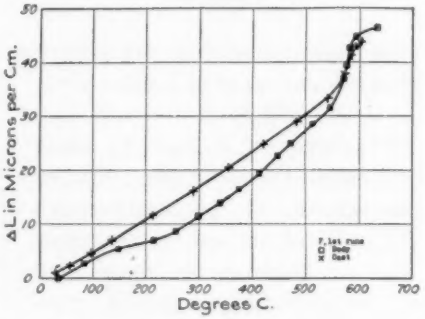

FIG. 30.

Figure 29 shows a comparison between the expansion of the body and glaze specimens of batch *F*, taken from another plate that crazed. The separation of the expansion curves shows that crazing should occur.

The agreement between the same body and the cast specimen of batch *F*, Fig. 30, is close enough so that a product free from crazing should be expected.

The expansions of the body and a glaze sample of batch *A* taken from a plate that did *not* craze are shown in Fig. 31. From the close agreement of the expansion curves a product free from crazing should be expected. It is doubtful if a closer match between any glaze and a body of this type could be obtained. On the other hand the results from the cast sample of batch A, Fig. 32, and the same body do not agree. The separation of curves would lead to the conclusion that the glaze should be crazed.

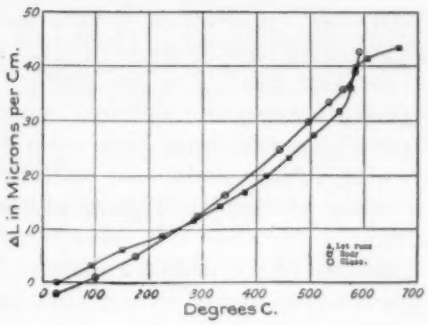

FIG. 31.

These comparisons of the expansions of glazes and bodies show that in the cases where crazing occurs there is a large difference between the expansions of the glaze sample and the body, while in the uncrazed ware a good match is found between the expansions of the glaze and body. In the cases of both the crazed and uncrazed ware, the cast specimens indicated conditions opposite to those actually found.

It will be noticed that the nature of the crazing, *i.e.*, whether tensional or compressional, should be indicated from the same curves. These, in Figs. 26 and 29, show that the body material contracted more than the glaze in the case of the two crazed plates. The glaze should therefore be under compression and develop compressional cracks. On examination this proved to be the case. Viewing the image of a straight edge at almost grazing angle from the surface of the plate, it was found that the glaze was thrust up on one side of the cracks and down on the other, which is a distinguishing characteristic of cracks caused by compression. Furthermore, examination with a microscope showed that the cracks were tightly closed and in no case showed an opening such as would have existed had the glaze pulled apart.

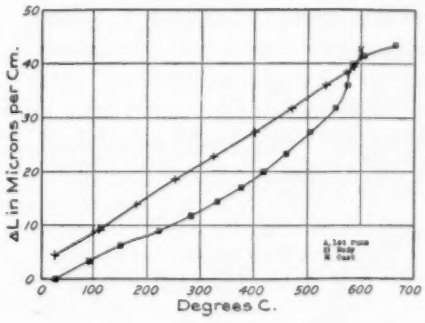

FIG. 32.

Measurements made on cast or drawn specimens cannot be relied upon to give the expansivity of the glaze on the finished ware.

To prevent crazing the expansion of the glaze from the finished ware must match that of the body.

Summary

To show the effect on the thermal expansions of different methods of preparing specimens of glaze, measurements were made by the interference method on the thermal expansions of six separate glazes representing two very different types, each prepared by three methods. Drawn glass specimens were made by melting the glaze material and drawing it into rods; cast specimens were melted into grooves in porcelain blocks, while glaze samples were taken from the finished ware.

Samples of the body were taken in several cases and their thermal expansions measured by the same method. The curves show that the condition of the finished product may be explained from the measurements on the glaze taken from the body, while the results of the measurements on specimens of cast or drawn material of the same batch composition were decidedly misleading.

The comparisons prove that the specimens must be taken from the ware if reliable data are to be obtained. They also show that the expansions of the glaze and body must be nearly the same if stresses sufficient to produce crazing are to be avoided.

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THE ELECTRICAL RESISTIVITY OF SOME CERAMIC MATERIALS AT ELEVATED TEMPERATURES AND A SIMPLE COMMERCIAL METHOD FOR ITS DETERMINATION.[1]

By Robert Maynard King[2]

ABSTRACT

This paper gives the values obtained by some resistivity measurements of several well known minerals used in the ceramic field. The values for some ceramic bodies are also given. A simple apparatus and method with which these values were obtained are described in detail.

Introduction

Many methods have been developed and used for the determination of the electrical resistance of ceramic materials and bodies at elevated temperatures. All of these methods are based on the assumption that Ohm's law holds for mineral compositions as well as for metals. This assumption is only approximately correct because of the physical and chemical changes which take place in heterogeneous mixtures. These changes are due to the passage of the current itself and to the effect of heat.

The methods developed by the Bureau of Standards,[3] by Brace,[4] and by Northrup[5] have been reviewed by Henry.[6]

These methods differ in detail, but in each case the outstanding problems are: (1) the assembly of an electrical measuring circuit which is sufficiently sensitive to measure accurately the small currents obtained and (2) the procuring of good contact between the terminals of the measuring circuit and the test piece. Since the method here described was developed to obtain reasonable accuracy only, strict scientific precision was not attempted. However, all precautions were taken which were consistent with simplicity and the desired accuracy.

It was found that a high resistance voltmeter was sensitive enough to obtain sufficiently accurate readings. A molten metal terminal

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[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (White Wares Division.) By permission Director, U. S. Bur. of Mines.

[2] Coöperation research engineer, U. S. Bur. of Mines, Ceramic Experiment Station, Columbus, Ohio.

[3] "Electrical Resistance of Various Insulating Materials at High Temperatures." Rept., No. 53, National Advisory Committee for Aeronautics.

[4] P. H. Brace, "Electrical Resistivity of Porcelain and Magnesia at High Temperatures," *Trans. Amer. Electrochem. Soc.*, **33**, 205 (1918).

[5] E. F. Northrup, "High Temperature Resistivity of Refractories." *Met. Chem. Eng.*, 123 (1914).

[6] A. V. Henry, "The Electrical Resistivity of Refractories." *Jour. Amer. Ceram. Soc.*, **7** [10], 764–80 (1924).

such as was used by the Bureau of Standards[7] is the most satisfactory but its use was prohibited in this case because it was necessary to use porous test pieces. Henry[1] used a layer of lamp black between the graphite terminals and the test pieces, but this created a reducing atmosphere and was not employed since oxidizing conditions were desired.

Description of Layout

A diagrammatic sketch of the apparatus is given in Fig. 1. A 640-volt power line was connected to the terminals of the rheostat R_1. (The rheostat "R" in Fig. 1 should be designated as R_1.) The test unit TU was placed in the furnace F. This unit consisted of two electrodes, three test pieces and a clamp which holds the electrodes and test pieces together. The details and assembly of the test unit and a sketch of the test piece are shown in Fig. 2. This unit was patterned after the one used by Henry,[7] but instead of a graphite clamp and graphite contacts a nichrome clamp and nichrome contacts were used. The test circuit includes the test unit, TU, the single pole double throw switch, W, and high resistance voltmeter, VM, and the rheostat, R_1. It will be noted that the test set includes three circuits: (1) the line circuit which includes the line switch S and the rheostat R_1; (2) the test unit circuit described above, and (3) the shunt circuit which included the voltmeter and the switch, W. This latter circuit is used for getting the line voltage and for the most important readings is only employed when the resistance of the rheostat R_1 is entirely in the circuit.

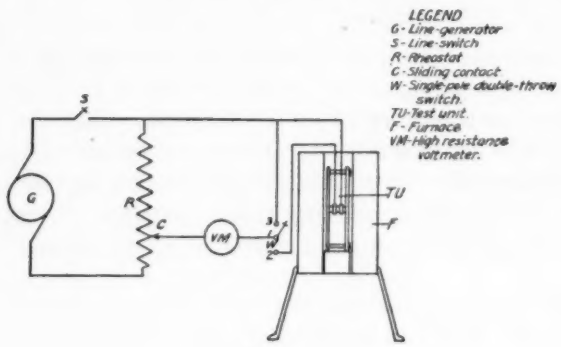

FIG. 1.

In addition to the above described circuits there are two others: (1) the furnace circuit which included the furnace, a controlling rheostat, and a 110-volt feed line and (2) the temperature measuring circuit which consisted of a chromel alumel thermocouple of No. 14 B & S gage wire, a Leeds and Northrup potentiometer, and a thermos bottle cold junction.

[1] *Loc. cit.*

Description of Equipment

The Power Line This is a plant supply line rated at 625 volts but which often registered as high as 660 volts and averaged about 640 volts.

The Line Switch This is a three pole single throw switch of the enclosed type.

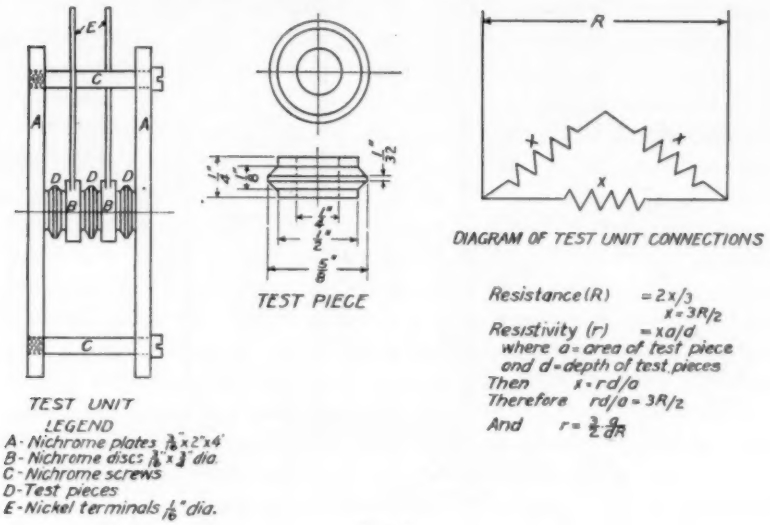

FIG. 2.

The Rheostat A laboratory rheostat of the wire wound tube type was used. It has a maximum resistance of 2870 ohms and a maximum current carrying capacity of 0.38 amperes.

The Voltmeter This was the only instrument used in this method for the determination of electrical resistance of the materials tested. This instrument was of the alternating current type having a resistance of 12,800 ohms and a negligible reactance. Alternating current was used in these measurements to obviate, as much as possible, irregularities caused by polarization when direct current was used.

FIG. 3.

The Furnace and Test Unit The unit has been described above. Figure 4 shows the details of the furnace construction.

Routine Procedure for Making a Resistance Test

Ohm's law states that the current passing through a circuit is proportional to the voltage applied and to the resistance of the circuit. The relation is

$E = RI$
when E = the voltage applied
R = resistance of the circuit
I = the current flowing

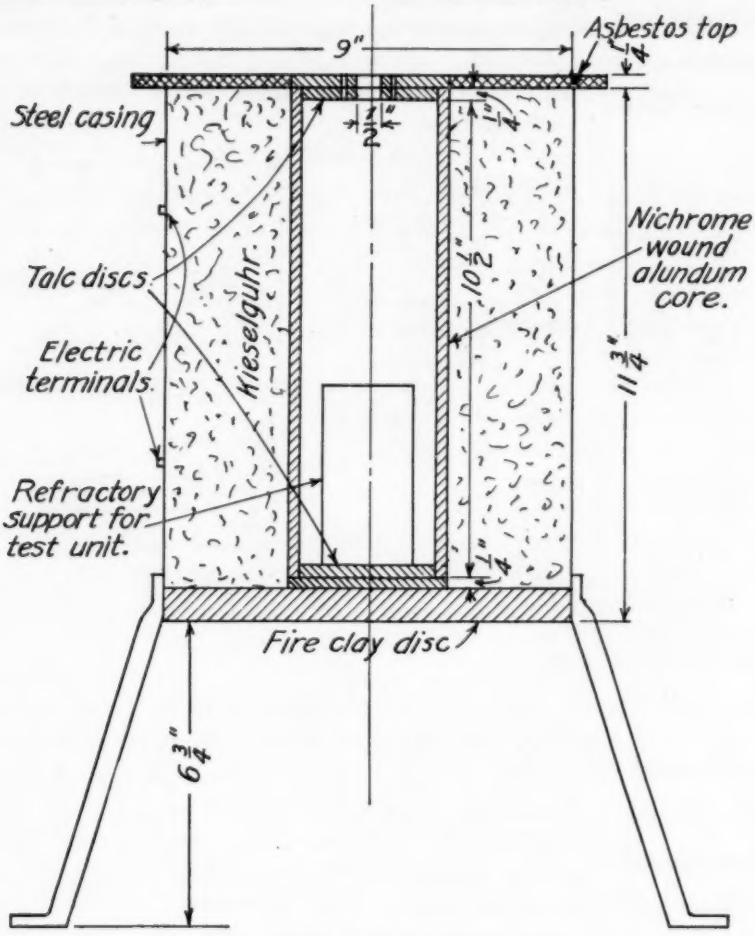

FIG. 4.

If according to the diagram shown in Fig. 3 we have a known resistance, r, placed in series with an unknown resistance, R, then if we apply a known voltage, V, by measuring the voltage drop, V_1, across r it is possible to calculate the resistance, R, as follows:
Let the voltage drop across R be V_2

$V_1 = r \times I_r$ Now, $V_2 = V - V_1$

$V_2 = R \times I_R$

But, $I_r = I_R$ Hence, $\frac{V_1}{r} = \frac{V - V_1}{R}$

Then, $\frac{V_1}{r} = \frac{V_2}{R}$

V and V_1 can be measured with the voltmeter and r is known. Hence the only unknown in the above equation is R. In referring to the diagram of the measuring circuit (Fig. 1) we have: V equals the line voltage measured by the voltmeter when the resistance of the rheostat R_1 is entirely in and the switch, S, occupies the position 1–3. The resistance, r, is that of the voltmeter which was accurately calibrated. V_1 is the voltage drop across r. R in Fig. 3 represents the resistance of the test piece. The readings were usually taken as follows: The test pieces were heated to the desired temperature. The switch, S, was thrown in and the switch, W, was thrown to the position 1–2. The sliding contact, C, was moved so that the resistance was gradually increased. When the voltmeter indicated the slightest deflection the switch, W, was thrown to the position 1–3 and a reading of the line voltage was taken. This is the voltage at which leakage begins. This data is important in some cases but is difficult to obtain accurately. The switch, W, was returned to the position 1–2 and the resistance increased until the full line voltage was applied to the test circuit. The voltmeter reading was then taken, the switch thrown to position 1–3 and a reading of the line voltage taken. The switch, S, was not allowed to remain closed except when readings were being taken as this causes undue heating of the rheostat. Since three test pieces are used in the test unit the resistance of one test piece is 1.5 times the resistance of the unit. This will be evident from the diagram and calculations shown in Fig. 2.

Accuracy of the Method

The voltage at which the greatest accuracy is obtained is the full line voltage. When the sliding contact of the rheostat is in such a position that the full line voltage is used a slight error will be introduced. Another factor in the accuracy of this method is the position on the voltmeter scale at which a reading is taken. The design of the A. C. voltmeter is such that the scale divisions at the low voltage end are much smaller for a given voltage than at the middle of the scale. For instance, the amount of the scale representing the first fifty volts is about the same as that representing ten volts at the middle of the scale. A third factor in the accuracy is the efficiency of the contacts between the metal terminals and the test pieces. It is extremely difficult to secure a satisfactory contact between refractory test pieces and the metal terminals without using some powdered material which is, in itself, a conductor. Lampblack is about the only conducting material sufficiently fine to use for this purpose and it could not be used for reasons previously given. However, by carefully grinding the faces of the test pieces on an emery wheel an accuracy of $\pm 15\%$ may be obtained when the conductivity is high enough so that an accurate

TABLE I

ELECTRICAL RESISTIVITY OF SOME CERAMIC BODIES AND MATERIALS

(Values given in ohms per Cm^3, 000 omitted)

Body of material	Firing temperature	713°C	739°C	762°C	787°C	812°C	837°C	862°C	887°C	913°C	940°C	963°C	990°C
Chemical porcelain	C13	84	81	81	84	83	80	72	60	46	38	28	22
Bur. Stand. No. 152	C16	548	434	380	356	312	294	272	266	252	232	250	251
Pressed talc	C11	Inf.	Inf.	Inf.	High	1272	750	460	270	250	250	—	204
Massive talc													
Maryland	1100°C	"	"	"	Inf.	Inf.	Inf.	Inf.	Inf.	High	796	225	167
Italian	"	"	"	"	"	High	793	285	225	165	147	116	89
Indian	"	"	"	"	"	Inf.	Inf.	Inf.	779	457	278	217	150
Chinese	"	"	"	"	"	"	"	"	Inf.	Inf.	Inf.	Inf.	Inf.
Beryl	C11	51	47	34	23	17	17	13	9	9	9	8	—
Spinel	C18	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.	Slight
Sillimanite	C18	"	1090	659	388	388	308	308	308	308	211	172	124
Cyanite	C18	"	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.	High	475	228	104
Andalusite	C18	551	334	551	556	556	265	265	226	200	200	165	138
Dumortierite	C18	193	175	146	146	123	110	107	86	81	70	70	52
Periclase	C18	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.	Inf.

reading can be made on the voltmeter scale. This accuracy figure was obtained by averaging differences for duplicate tests on several different materials.

Table I gives the results obtained.

TABLE II

DESCRIPTION OF BODIES AND MATERIALS USED

Chemical Porcelain		Bureau of Standards Body No. 152	
Composition of body	Per cent	Composition of Body	Per cent
N. Car. kaolin	15.00	Ga. kaolin	10.00
Fla. kaolin	10.00	Fla. kaolin	10.00
Tenn. ball clay, No. 5	25.00	N. Car. kaolin	10.00
Calcined kaolin	20.00	Del. kaolin	10.00
Flint	10.00	Calcine No. 19	40.00
Canadian potash feldspar	20.00	Calcine No. 14	20.00
			100.00 mature C 16

Calcine No. 19		Calcine No. 14	
Composition	Per cent	Composition	Per cent
Kaolin	70.20	Magnesium Carbonate	18.20
Calcined Al_2O_3	27.80	Flint	25.80
Boric acid	2.00	Kaolin	56.00
	100.00 cal. at cone 20		100.00

Pressed Talc This talc was a California product, almost pure, and closely approximated a theoretical composition. A 300-mesh powder was mixed with linseed oil and pressed into test pieces in a steel die with a standard screw press. The test pieces were fired to cone 11. Talc has the composition represented by the formula $3MgO \cdot 4SiO_2 \cdot H_2O$.

Massive Talcs These talcs were of the physically uniform variety used in making machined talc insulation. The region producing each variety is specified.

Beryl This mineral was the commercial product and contained 11 to 12% beryllium oxide. The formula of beryl is $3BeO \cdot Al_2O_3 \cdot 6SiO_2$.

Magnesia Spinel Magnesia spinel has the formula of $MgO \cdot Al_2O_3$. The material used in making these tests was the electric furnace product and had the following composition: Al_2O_3 72.95, Fe_2O_3 0.25, SiO_2 0.55, and MgO 27.78, a total of 101.53.

Sillimanite The material used was from a deposit in India. An analysis gives: Al_2O_3 62.40, SiO_2 32.29, FeO 2.14, TiO_2 2.10, and loss on ignition a total of 99.85.

Andalusite This material was furnished by Mr. Riddle of the Champion Spark Plug Company and came from a deposit in California. A typical analysis of this material is: Al_2O_3 55.78, SiO_2 35.06, Fe_2O_3, 94, TiO_2 1.64, and loss on ignition 5.76.

Cyanite This material was obtained from the Virginia deposits near Charlotte Court House and had the following analysis: Ignition 0.41, SiO_2 37.28, Al_2O_3 59.93, Fe_2O_3 0.73, and TiO_2 1.20. The formula of the above three minerals is $Al_2O_3 \cdot SiO_2$.

Conclusions

Of the three minerals, cyanite, sillimanite, and andalusite, which have become noted for the formation of mullite in ceramic bodies, the cyanite sample tested seemed to be the best in electrical resistance, with sillimanite and andalusite next in order. This may have been due in part to the purity of the material.

Magnesia spinel has a higher resistance than any one of the three above minerals, and higher than any material tested except the Chinese talc and periclase.

All talcs tested have a higher resistance than either sillimanite or andalusite, but only one talc showed a resistance higher than cyanite.

It seems reasonable to conclude from this data that if we take the composition $Al_2O_3 \cdot SiO_2$ as a starting point and substitute MgO for either Al_2O_3 or SiO_2 the electrical resistance will increase, as the MgO content increases.

A NEW GLASS STONE: $Na_2O \cdot 3CaO \cdot 6SiO_2$[1]

By Albert B. Peck

ABSTRACT

Attention is called to a stone of different composition than any heretofore recorded, and but recently possible of identification by petrographic-microscopic means through the work by Bowen and Morey on the system Na_2SiO_3–$CaSiO_3$–SiO_2. Various ways by which attempts were made to determine the composition of the crystals are described and a summary of the optical properties of these crystals from three sources is given. Probable places for the formation of these stones in the tank are also indicated.

Several years ago the writer received a glass stone for petrographic identification, the optical properties of which proved to coincide with those of no compound previously described in Bowen's[2] very complete description of such phenomena. Hoping that Dr. Bowen might have some later information on the subject, the stone was sent to him and the first negative result was confirmed.

In an attempt to gain some indication of its composition, the finely-ground mixture of crystals and glass was treated with various acids. Sulphuric acid had no effect upon either the crystals or glass. Nitric acid decomposed both the crystals and glass, leaving a skeleton presumably of SiO_2 in place of the crystals. Hydrochloric acid decomposed the crystals, again leaving a skeleton of SiO_2, and hydrofluoric acid dissolved both the crystals and glass. Since ordinary analysis would give the total composition of the crystals and glass combined, which would be the same as that of the undevitrified glass, the solution obtained by leaching the crystals with hydrochloric acid was analyzed and the ratios of the principal oxides present were determined as follows: $CaO:Na_2O = 2:1$ and $SiO_2:CaO+Na_2O = 1.8$.[3] Although microscopic examination showed very conclusively that the crystals were not completely dissolved, the composition of the solution further confirmed the fact that they represented an entirely new type of glass stone. But since no data were available on the ternary compounds of Na_2O, CaO, and SiO_2, the exact identity of these crystals still remained clouded, and owing to the lack of definite chemical information concerning the crystals in question, publication of all data concerning them was withheld.

A few years later Bowen[4] was lead to suspect that these crystals might be the same as those of the natural mineral rivaite, the composition of which had been given as $(Na_2, Ca)Si_2O_5$. Examination of

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Glass Division.)

[2] *Jour. Amer. Ceram. Soc.*, **1**, 594–605 (1918).

[3] Private communication.

[4] *Amer. Mineralogist*, **7**, 64–66 (1922).

the original rivaite proved that it was in reality only wollastonite embedded in a glass, a condition quite common for glass stones. This disproved rivaite as a distinct species. Further examination of some synthetic "rivaite" showed that it in turn consisted of a glass in which were embedded some crystals similar in optical properties to those of the hitherto unidentifiable glass stone, but the presence of considerable glass in the synthetic "rivaite" still left the true composition of the crystals in doubt.

Soon after this, Insley[1] sent the writer a stone which apparently contained the same unknown crystals but in addition they appeared to be mixed with two other materials, perhaps some partly decomposed sodium carbonate and calcium carbonate. The stone effervesced with hydrochloric acid, and decomposed and became chalky upon short exposure to the air. The writer's stone is still perfectly fresh after years of exposure to the air. Insley reported his stone to have been found in the dead corners of a tank. Soon thereafter, in a description of various stones in glass, Insley[2] recorded the optical properties of these crystals, which were essentially the same as those for the original crystals noted by the writer. Insley described them simply as a sodium calcium silicate.

At a still later date the writer again attempted to obtain the composition of these crystals by leaching the powdered mixture of crystals embedded in glass with hydrochloric acid and later dissolving the remaining siliceous skeleton of the crystals with sodium hydroxide. This method gave the proportions of the constituents as $2Na_2O \cdot 3CaO \cdot 9SiO_2$, but it was clearly evident that all of the skeleton of silica had not been dissolved by the alkali.

Recently Morey and Bowen have published their findings for the system Na_2SiO_3–$CaSiO_3$–SiO_2.[3] In this system they found a compound $Na_2O \cdot 3CaO \cdot 6SiO_2$, which corresponded closely to the crystals found in the original glass stone. They have called attention to this in their paper. The crystals are long and slender, and have a positive optical elongation. Those noted by the writer were always diamond shaped in cross-section, which with the parallel extinction would indicate orthorhombic crystallization, to which they have been assigned by Morey and Bowen. Insley, and Morey and Bowen, also mention hexagonal and octagonal cross-sections. The optical properties from the different sources follow.

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[1] Private Communication.

[2] *Jour. Amer. Ceram. Soc.*, **7**, 14–18 (1924).

[3] *Jour. Soc. Glass Tech.*, **9**, 226–65 (1925).

	Peck	Insley	Morey and Bowen
α	1.565	1.562	1.564
β	1.570		1.570
γ	1.580	1.577	1.579
Optical sign	positive	positive	positive
Elongation	γ	γ	γ
Optic angle (2V)	large about 65°		75°
Crystallization	orthorhombic?		orthorhombic

The stones in the possession of the writer occur as nodules up to two inches or slightly greater in diameter, surrounded by clear glass. They have very much the appearance of wollastonite stones and are true devitrification products. The stones were first found in the sheets as they were drawn from the tank.

Morey and Bowen point out that the crystals forming these stones, as well as those of most other compounds of Na_2O-CaO-SiO_2, are rather unstable and exist without dissociation only through a small range of temperature. Hence, they will be formed only under very specialized conditions. Furthermore, the compound $Na_2O \cdot 3CaO \cdot 6SiO_2$ has a decomposition point of only 1047°C, the lowest decomposition or melting point of any of the compounds in the system, although it may exist in pure Na_2O-CaO-SiO_2 mixtures as low as 725°C. The presence of Insley's crystals in the dead corners of a tank is suggestive in this connection.

The stone described in this paper was probably due to some other cooling influences. As these accumulations were freed either mechanically or naturally, stones would appear in the sheets. A higher temperature in the drawing chamber, perhaps only very slightly greater on account of the low dissociation point of this compound ($Na_2O \cdot 3CaO \cdot 6SiO_2$), would probably eliminate the diffiulty.

Thus another "trouble maker" has been added to the list of glass stones which may be identified by petrographic-microscopic methods, and with its identification assured, correctives for its elimination when it occurs can be applied. This study shows how elusive is the identity of some of these compounds until exact physical-chemical and petrographic-microscopic methods are brought to bear upon them.

The writer here wishes to express his thanks to Dr. Bowen and to Dr. Insley, both of whom have furnished information making this note possible, and especially to Wilbur F. Brown of the Libbey-Owens Sheet Glass Company from whom the original stones were obtained.

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A MODERN SEWER PIPE PLANT[1]

By W. D. Richardson

ABSTRACT

A sewer pipe plant design including radical departures from plants in operation now is described. Tunnel driers of special design are suggested as most practical. Salt glazing in continuous kilns, using gas or oil as fuel, is discussed. A feeder for introducing the salt into the kiln is described.

Last year I was engaged to test the clays that were available and make an estimate of the cost of a one-press sewer pipe plant. In this investigation the plants that had been most recently built and the drawings of one that was then being built were examined. I found

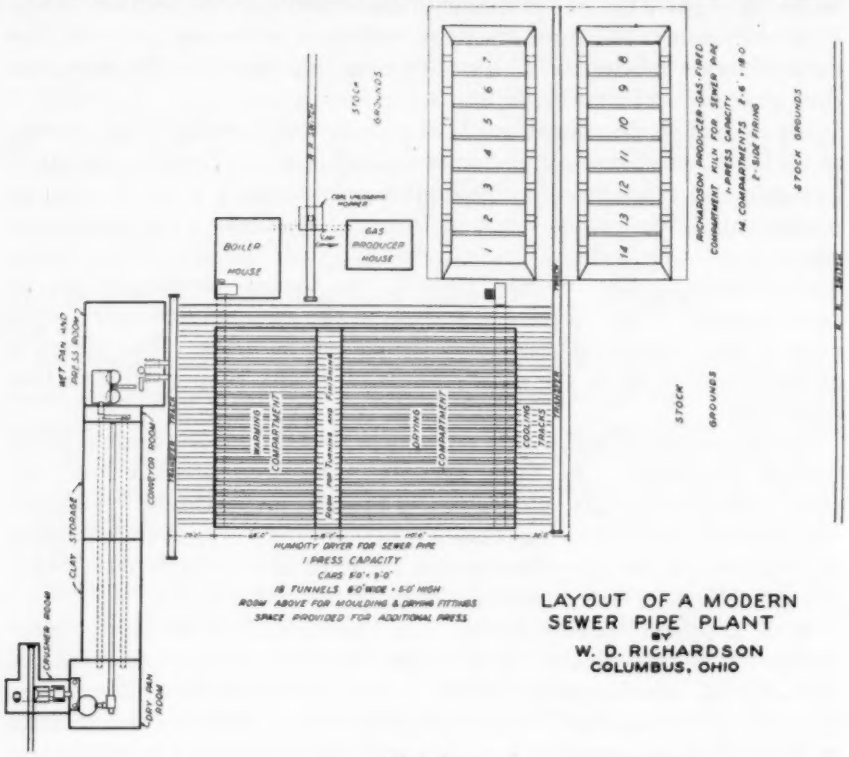

FIG. 1.

that in the past twenty years or more very little change or improvement had been made in the style or arrangement of sewer pipe plants, and that practically no economies in the manufacture had been introduced. A few improvements had been made in machinery, but there was the same large three or four story building for drying and finishing the pipe and the same round downdraft kilns for firing them. The

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Heavy Clay Products Division.)

expense of handling and storing so many pipe in the process of drying and the waste of fuel in firing set me to giving more thought to the possibilities of correcting these deficiencies than the occasion really demanded, since the project of my clients had not yet been capitalized and I had no contract for further engineering service. However, I was sufficiently interested to make a preliminary layout of a plant embodying some rather radical changes, especially in the equipment for drying and firing of the pipe.

I am pleased to bring before the Heavy Clay Products Division of our SOCIETY my idea of a modern sewer pipe plant, soliciting your

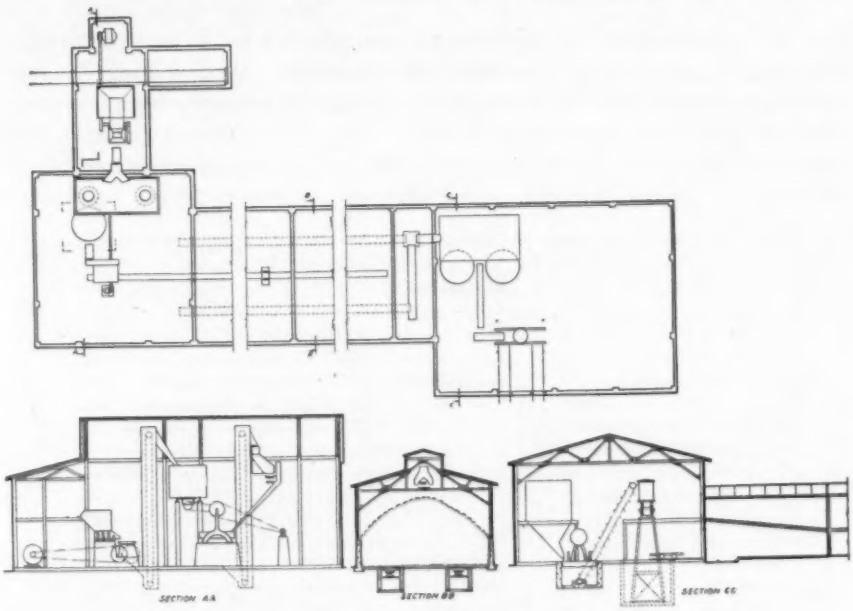

FIG. 2.

criticism. The pictures will show the general arrangement of the plant and will enable me to describe the special features. I have gone over the design many times, and have sketched the details of the drier, the only feature that is, in part, new to me, though I have not taken time to make working drawings of it.

Clay Preparation and Storage

The clay preparing and clay storage features are such as we commonly make for many heavy clay products plants. The main purpose of the design of storing the clay, ground and screened, is to secure a homogeneous body of uniform composition from hour to hour, day to day, and month to month throughout the year. All clay formations vary more or less

from top to bottom of the deposit and it is practically impossible to mix thoroughly the different strata in mining. The storing of raw clay as it comes from the mine, or even of crushed clay, does little good.

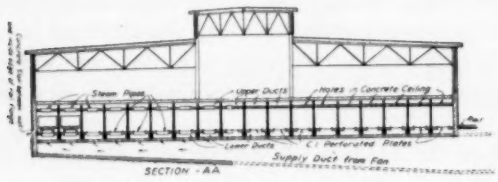

FIG. 3A.

Clays can only be well mixed when they are in a finely pulverized condition and uniformity can only be secured by storing the pulverized clay in bins 15 to 20 feet high. In this way the variations in the clay as mined are evenly distributed over the bin by an automatically traveling tripper on a troughing belt conveyor. With a long enough and high enough pile, fed down onto a reclaiming conveyor underneath the bin, a uniform material is obtained. By this uniformity of material and homogeneity of the body of the ware we have many times overcome defects that were thought to be due to improper drying or firing.

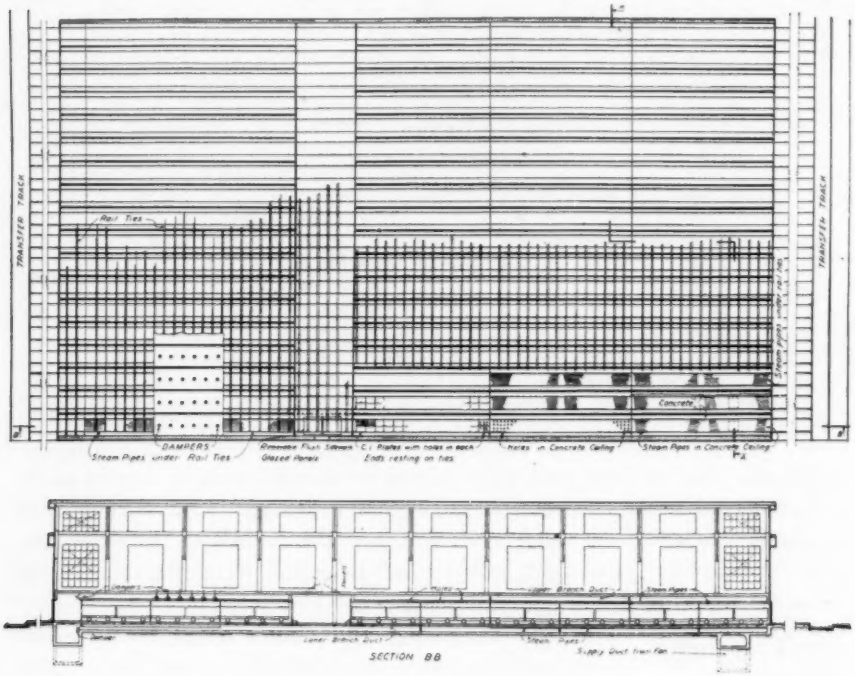

FIG. 3B.

A secondary advantage of ample clay storage is no delay in manufacture due to interruption in mining or preparation operations.

Drying The drying of sewer pipe on cars in a tunnel drier is not new. I saw such a plant more than twenty years ago. I do not know whether it is in operation today, but if it is, the drier has doubtless been much improved, though it was apparently successful at that time. We have learned a good deal about drying clay products since then and we now know that in a closed room, the space around the ware being comparatively small, where the temperature, the humidity, and the circulation are under control, the most elaborately molded clay bodies can be dried in a fraction of the time that they were formerly dried in working or drying rooms and with less damage to the ware. Why should not sewer pipe manufacturers take advantage of this?

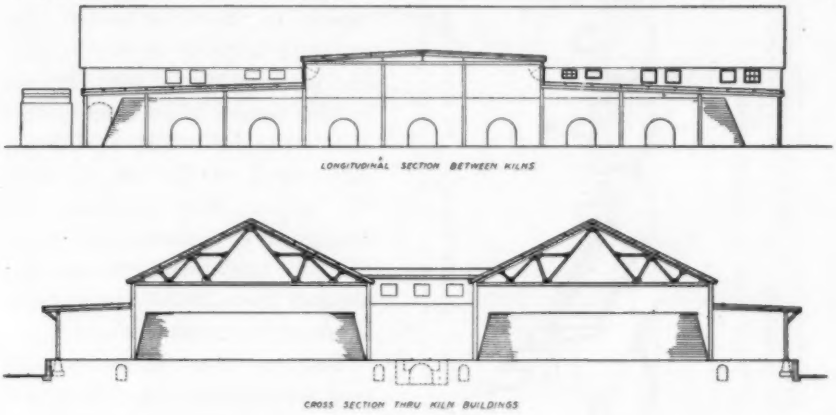

FIG. 4.

Why build such strong high buildings with so little of the cubic contents utilized and be obliged to provide space for carrying pipe so long in the process of drying? Of course, a certain amount of various sizes of dry pipe must be available for setting kilns to advantage, but probably with proper planning, such stock need not be so excessive and could be carried on cars in tunnels at small cost. Fittings are molded, dried and stored in a room over the tunnel drier from which they can be taken to kilns as required.

The cars I have in mind for this plant have a perforated steel platform 6 x 9 feet, the platform being level with the floor of the press room. Such a car would hold six 24-inch pipes, and could be pushed by one man into drier and from drier onto transfer car and from transfer car into kiln. The cars would, of course, be moved through the drier by power in a simple manner.

There are two permanent compartments in the drier, the first for warming and preliminary drying to a "leather hard" condition for finishing the larger sizes of pipe; the second compartment is for rapidly

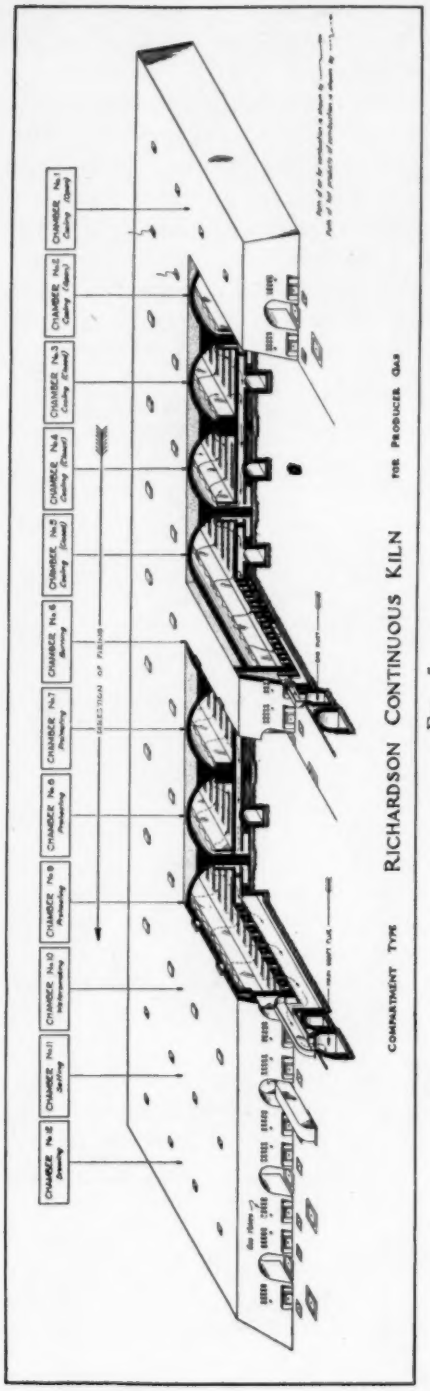

FIG. 5.

drying the pipe by progressing them gradually through sections of increasing temperature and decreasing humidity. For this I have used my compartment tunnel drier, the tunnels being divided into compartments for up-and-down draft circulation by means of steel plate baffles on the rear of every other car, fitting rather closely to the sides and to the top and bottom of the tunnel and forming movable partitions in the tunnel that force alternately the desired up-and-down movement of the air through the pipes and prevent the longitudinal circulation over the top, under the bottom and around the sides of the cars as is usual in tunnel driers.

Between the two permanent compartments of the drier is a room for finishing or turning the larger sizes of pipe on the cars. In this room there are, over each track, trap doors in the top that are easily opened for light and ventilation when finishing pipe or moving cars from the first to the second compartment, but which at other times are closed down for a passage way on the floor of the fittings room above.

It is designed that two cars at a time be moved through the tunnel. Only one of these cars will be in the finishing room at a time. By placing two cars in the tunnels and taking two cars out of the tunnels there will

always be partitions at the same points.

Though the tunnels are heated by steam pipes under the tracks of each tunnel and at top of the tunnel in the last two sections at hot end, yet the circulated air is heated either by a small steam heater or by the heat from a cooling kiln. This heated air is blown into the drier by a fan and distributed in the usual manner. The circulation of the air in the tunnels and the removal of the vapor is by another fan.

In the first, or warming-up compartment of the drier, there is little or no artificial circulation and absolutely none in the first two sections. Circulation of high humidity air is provided in the third section.

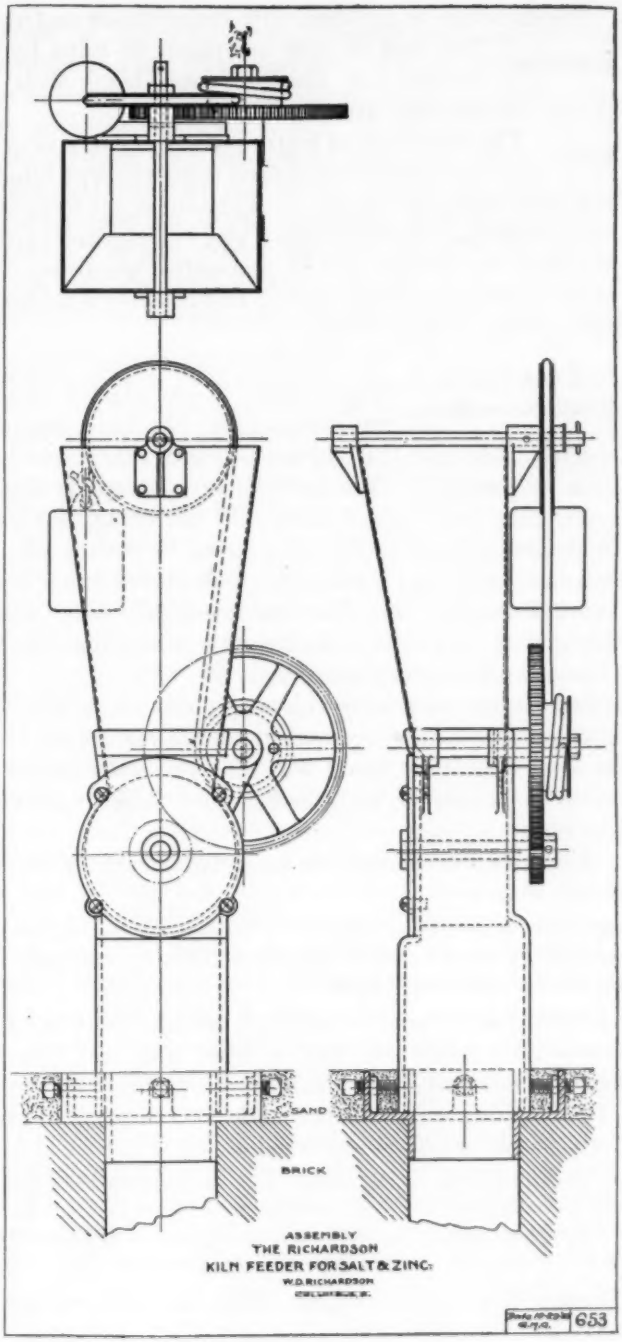

FIG. 6.

The drier can be provided with temperature and humidity controllers.

Transfer The cars of pipe are taken to kilns by the usual electric transfer car, the kiln doors being wide enough to permit of the car passing into the kiln.

Kilns The next radical feature of the modern sewer pipe plant is the kiln, a producer-gas fired compartment kiln, fully regenerative and continuous in operation. The kiln is not new; its present form has been developed through many years of experience with such kilns and has been for a long time in successful operation. The only new and untried thing about the kiln in this country is its use for the firing and salt glazing of sewer pipe.

Salt Glazing in Continuous Kiln We have been asked many times in the past ten or fifteen years if salt glazing could be done in the continuous kiln. We have answered that we could see no reason why it could not be done; that it was being done successfully in Germany. We know of no attempt in America to salt glaze sewer pipe in the continuous kiln nor of any systematic experiments by technical men to do salt glazing in such a kiln, except that Ellis Lovejoy years ago successfully salt-glazed brick in a Guthrie kiln at Union Furnace, Ohio. The making of salt-glazed brick was out of their line and the demand at that time was small, so the production of salt-glazed brick was not continued.

Sewer-pipe men have reasoned that salt glazing could not be done in a continuous kiln because fumes would injure the pipe being preheated. In what way, they could not tell, and when sifted down it has been found to be only an empirical opinion based neither upon theory nor practice.

About two years ago, an unsigned article in the *British Clayworker* stated that

> continuous kilns are not satisfactory because the salt vapors would be carried into a succeeding chamber before the pipes in the latter were ready for salting, and consequently such pipes would be spoiled.

I immediately wrote to the editor asking him to get a specific statement from the writer as to just in what way and why the vapors of the decomposed salt would injure the ware that was being preheated. After waiting two months and receiving no answer I wrote again and finally the editor answered as follows:

> The truth of the matter is that we made some inquiries that were not satisfactory and we have since had to follow these up in quite another direction. We are now in touch with a German firm in the matter and hope in the course of a very short time to be able to give you the information you require.

Though this was in August, 1924, the information has not been received.

I have asked some of our well-known ceramic chemists for their opinion on this matter and all state that they do not think the salt vapors passing out of the compartment under fire would have injurious effect on the ware being preheated.

Salt Glazing with Oil or Gas

Sewer-pipe men have said that salt glazing could not be done with gas or oil, but no finer salt-glazed sewer pipe are made anywhere than those in Ohio fired with natural gas. Of course, there is no reason why this should not be so. They could be fired also with producer gas.

I have a clipping from the *Tonindustrie Zeitung*, No. 73, 1912, which states:

> The best results for firing of sewer pipe in continuous kilns have been obtained in the ones which are gas-fired. Such kilns have also been used for stone ware. The regulation of the firing has no difficulties, and it can be fired either oxidizing or reducing. The salting is done from the top of the kiln, through properly constructed holes, and the sewer pipe have always shown as good glaze in the bottom as on top. It is claimed that such gas-fired continuous kilns have produced 96% first-class sewer pipe.

Salt Glazing in Continuous Chamber Kilns

H. G. Schurect secured information through technical journals which was mostly to the effect that though there was a saving in fuel in the continuous kilns the glaze was not as good as that produced in intermittent kilns. I have looked up these references in the *Tonindustrie-Zeitung* and in *Keramische Rundschau*. These answers are to the effect that salt glazing is done successfully in such gas fired compartment kilns but it is necessary that the kiln be so constructed that during the salting the compartment can be disconnected from the other compartments and closed tightly with dampers when required. I am convinced that the kilns we are now building are superior for salt glazing.

For feeding the salt into the kiln in a continuous stream as fast as it will volatilize, I have devised a small automatic feeder, geared and operated by a weight that will feed a charge of salt as slowly as may be desired. If thought best fine coal may be mixed with the salt in the charge. With this apparatus feeding in this manner, it is believed that quicker and better results will be obtained, as the salting will not cool down the kiln and the temperature and kiln atmosphere are under instant control by valves.

Salt Glazing in Car Tunnel Kiln

I have also a car tunnel kiln that I believe is better adapted for firing sewer pipe but I consider the tunnel kiln more of an experiment and hesitate to take the responsibility of recommending it. The compartment kiln, however, is safe, reliable, flexible, and economical.

SCHULTZ BLDG.
COLUMBUS, OHIO

E-90-P COMPARATIVE TEST OF HAMMER MILL PULVERIZER AND DRY PAN FOR CRUSHING STREATOR SHALE[1]

By D. P. Ogden

ABSTRACT

In the machines as described below the following points are discussed: (1) the grinding action, (2) energy consumption per ton ground, (3) capacity to produce fines six-mesh and under, (4) to determine the operating characteristics of the hammer mill. The conclusions given are: (1) The dry pan will not grind shale chunks larger than 15 inches maximum diameter, nor chert nodules of any size. The hammer mill grinds easily in one operation all chunks small enough to go through the 20x42-inch hopper opening and all chert nodules. (2) The energy consumption of the dry pan as compared to the hammer mill in kw. hrs. per ton of fines through six-mesh is approximately as 1.40 to 1.25. (3) The maximum capacity of the Frost 9-foot dry pan with ¼-inch screen plate openings was known to be approximately 25 tons through six-mesh per hour. The maximum capacity of the 30x42-inch Williams hammer mill as reached in these tests with hand feeding was found to be 56 tons total feed and 42 tons through six-mesh per hour. This figure could have been greatly exceeded if the material could have been fed more rapidly. The dry pan tailings coarser than six-mesh compared to the hammer mill tailings of the same coarseness are as 40 to 25%. (4) The hammer mill is more efficient than the dry pan in practically all respects if properly set up and operated, but it is easily possible to secure less efficient results from the hammer mill, particularly if the feeding is not properly regulated.

Introduction

This test was a practical tryout of the hammer mill as a substitute for several dry pans for the grinding of mine-run shale in one operation in the production of shale face brick. The laboratory work was necessary to correlate and compare the performance of the two machines. In all cases the data obtained is from the same shale deposit and was mined under identical conditions and at the same time of the year.

Earlier Test with Pulverizer

In 1922 a test was run on the "American Ring Pulverizer" in the plant of the Decatur Brick Company at Decatur, Illinois. The data from this test showed that considerable improvement might be hoped for if the very severe momentary overloads on the motor could be avoided by storing more kinetic energy in the rotating system either: (*a*) by increasing the weight of the fly wheels, (*b*) by increasing the rotational velocity of speed in revolutions per minute of the hammer shaft. Accordingly, when the pulverizer tested was ordered from the manufacturer it was specified to be equipped with two extra heavy fly wheels. Also, this machine was direct connected to a 1200 r.p.m. constant speed induction motor, whereas the machine at Decatur was driven through a belt at a speed of less than 600 r.p.m.

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Heavy Clay Products Division). Received March 19, 1926.

The Dry Pan The dry pan was the Frost 9-foot dry pan of the conventional design having screen plate openings approximately $\frac{1}{4}$ inch across. It was operating under its normal production conditions.

The feed was by an inclined belt conveyor running in the bottom of a trough and consisted of mine-run shale, except that hard nigger-heads or chert nodules encountered had to be thrown out by hand, and it was regular practice to split up, by means of a pneumatic air tool, chunks having any dimension greater than 18 inches.

This feeding, for a capacity of approximately 35 tons per hour required the services of two men and an 18-inch wide belt conveyor.

This dry pan was driven from a line shaft which also served a brick machine and miscellaneous auxiliary equipment. In making the energy consumption determinations for the dry pan the idling load of the motor and line shaft were measured by disconnecting all machines from the line shaft. Next, the total load of the line shaft and of the dry pan grinding shale was measured, such that by subtracting the idling load of the line shaft from the total load of the line shaft and dry pan, the energy delivered to the dry pan could be closely approximated. The error in this method, if any, would be such that the total load of the dry pan would be greater than the determination, for the reason that the energy lost in the belt driving the dry pan would be partly charged to the line shaft. The determinations as made, however, were the best that could be had without setting up an individual motor to drive the dry pan, which was virtually out of the question and not considered necessary.

Hammer Mill The hammer mill is described by the maker as a "Williams 30x42 Decksweeper Pulverizer" and in this test was direct connected to a G. E. Co. 1200 r.p.m., 100 h.p. squirrel cage motor.

A temporary timber frame was provided for supporting the hammer mill and motor. Also, a little wooden frame work over which tarpaulins could be pulled to protect the machinery during inclement weather was provided. The motor compensator and meter current transformers were mounted on this wooden frame work. A wooden guard was put around the flexible coupling between the motor and hammer mill so that stray chunks of material which might fall on this rapidly rotating coupling would not be a source of danger by being thrown from it. These details are well shown in Fig. 1.

A charging platform immediately adjacent to and at a slightly lower level than the Streator Brick Company production shale car track was built of heavy planks supported on a timber frame such that this platform could receive mine-run shale dumped from the side of the

production rocker dump car. The height of this charging platform was made such that shale pushed over its east edge would fall directly into the hopper of the hammer mill. The intention in this arrangement was to make it as easy as possible to push rapidly, large quantities of shale into the hammer mill hopper. This arrangement worked out only moderately well because of the high capacity of the machine being tested. The procedure in this test was for as many men as could be gotten around a measured pile to push and shovel as fast as they could into the hopper opening of the machine. This arrangement is shown in Fig. 2.

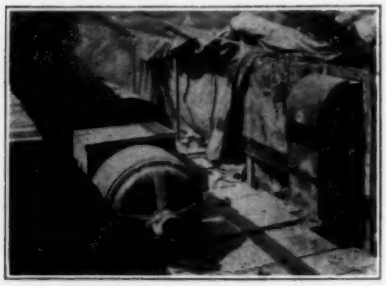

FIG. 1.—Motor and drive end looking north.

Some difficulty was experienced with material flying back out from the hammer through the hopper opening. After the photograph of Fig. 2 was taken a hood was built over this hopper opening and brought up to a vertical wall built of boards. The hopper opening itself was closed off by pieces of 2 x 4 suspended by holes drilled through their top ends, which almost closed the opening leading to the hopper such that it was possible to push the shale to be fed through this swinging wooden curtain, but such that the pieces flying back could not get out. This arrangement was found to work very well indeed, and virtually to eliminate the difficulty from flying pieces. As would be expected this trouble was greatest when hard and flinty material was being fed into the machine.

An ordinary service type watt-hour meter was used to make the determinations of electrical power and energy fed to the motor. By removing the cover of this meter and putting a small mark on the meter disk it is possible to get the time of one revolution of the meter disk by using a stop watch. Thus, this instrument can be used to secure what amounts to an average power determination during the time of one meter disk revolution since a definitely known amount of energy is consumed for each revolution of the meter disk. This time is so short (from 1 to 5 or 6 seconds) that these average power determinations in reality can

Fig. 2.—Charging platform looking northeast.

be considered as instantaneous maxima. Actually these determinations of maximum demand are much more satisfactory in tests of this nature than the readings of an indicating watt-meter, for the reason that the indicating watt-meter pointer is apt to move so rapidly that it is difficult to read at all. The average power and the total energy consumed during any definite time are at once obtained by merely counting the meter disk revolutions and measuring the number of seconds from the start to the finish of the run. The data that it is necessary to record for these determinations is shown below. The method of mounting this meter is shown in Figs. 2 and 3.

FIG. 3.—Measuring boxes on charging platform.

The weight of shale to be used in each run was greater than the capacity of any scale that could conveniently be moved to the location of the test. Therefore two bottomless boxes were made having capacities of one cubic yard, and one-eighth of one cubic yard respectively. In this way it was possible to fill up both boxes from the same pile of shale for any particular run. These boxes are clearly shown in Fig. 3. Next, the small $\frac{1}{8}$-yard box which had been placed on a steel plate before filling, was picked up and set on a platform scale and the weight of the shale determined. It was assumed that the weight of the large box full of shale was exactly eight times the weight of the smaller box and in this way the weight of the large box full of shale was computed.

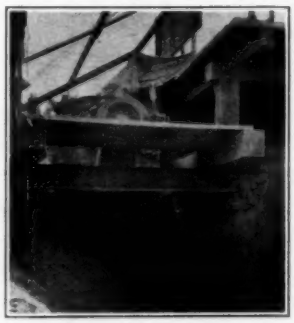

FIG. 4.—Discharge of hammer mill looking south.

The timber platform carrying the pulverizer and motor was so constructed that a space approximately eight feet high was left free under the discharge of the hammer mill. Just before each run was started this space was cleared out of the shale that had been previously ground and a clean wheel barrow was put directly under the discharge opening of the machine. Thus, when the run was started, part of the tailings or discharge from the hammer mill went into the wheel barrow. Actually in practically all runs the wheel barrow was entirely buried and had to be dug out. The wheel barrow load was then taken out from under the hammer mill and

TABLE I

E–90–P Tests of Williams 30x42 in., "Decksweeper Pulverizer" directly connected to G. E. Company 100 h. p., 1200 r.p.m. Type KT Motor at Streator (Ill.) Brick Company between 7–1–25 and 9-15–25. Frost 9–ft. Dry Pan Driven from Line Shaft ¼-in. Screen Plate Openings.

Run no.	Date	Time in sec.	Meter disk revs.	7 Kw. hrs.	Av. kw.	Shale fed in hopper Kind and siz	Wt. (tons)	Kw.hr. per ton	Sieve test sample no.	Remarks
1*a*	7–1	79	10	.600	27.5	Mine-run shale	10	1.2	1	2 men shoveling; no large chunks
4	7–3	63	8	.480	26.4	Spoil pile nodules	.35	1.28	4	3 men feeding nods to mach.
5	7–10	50	10	.600	43.2	Mine-run shale			5	
10	7–18	17.3	47	2.82	58.7	Mine-run shale	2.7	1.05	10	6 men feeding machine
16	8–5	76.8	10¼	.10	100.25	Dry pan on mine-run shale		1.41	16	Loaded heavily Production operation
20*a**	8–29	285	20	1.2	15.4	Mine-run shale	1.35	1.12	20*a* 20*b**	These tests were made with *roller out and every other row of hammers out*
26	9–3	100	11	.66	23.7	Mine-run shale with chunks 30 in.	.468	1.4	26*a* 26*b*	Roller back ½ in. (limit) alternate hammers in each row out
29	9–5	36	4	.24	24	Chunks and mine-run shale	.264	.91	29*a*	Roller in, alternate rows of hammers out
	9–5	15	3.5	.21	50.5	Large chunks	.27	1.3	29*b*	Roller in, alternate rows of hammers out
35	9–14	125	11	.66	19	Mine-run shale	.1	6.6	35	1 large chunk
40	9–15	31	11¾	.72	82	Large-chunks and mine-run shale	.5	1.44	40	
41	9–15	195	22	1.32	24	Mine-run shale	.1	1.32	41	Extra wet
42d	9–15	Sample taken from bin over brick machine screened shale							42*d*.	

* Sample 20*a* taken from E side of pit under machine. Sample 20*b* taken from W side of pit under machine during same run as 20*a*. Coarse tailings rebounded from E side of machine to W side of pit.

dumped on a large steel plate. The pile thus made was formed into a cone and quartered in the approved fashion. Diagonally opposite quarters were discarded and a smaller cone was made. In this way the samples were reduced to such size that they could be conveniently put into cardboard cartons to be carried to the sieve test laboratory. In the laboratory a Tyler sample splitter was used to further reduce the samples to approximately 500 to 1000 grams, such that they could be contained in Tyler standard sieves. The discharge opening is shown in Fig. 4. The sieve test data was obtained in the usual way by using a Tyler rotap sieve shaking machine. Determinations were made with screens at each of the following sized openings: 1.050-, .525-, .263- or 3-mesh, 6-, 8-, 10-, 14-, 20-, 28-, 35-, 65-, and 150-mesh.

Data

In this test a total of 41 runs was made. However, many of these runs are not very interesting for the reason that they were made only to teach the men concerned what to do, or to try out some minor change that had been made in the arrangements. The runs shown in Table I are those which correspond to the curves shown and are believed to include the most interesting data of the test.

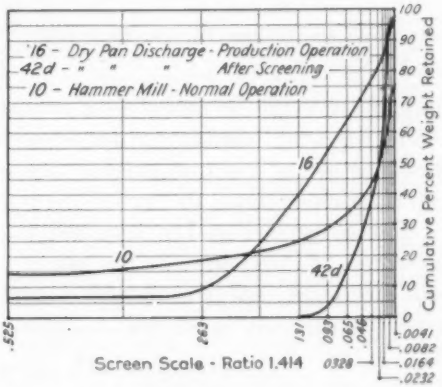

FIG. 5.—E–90–P Test of Williams 30 x 40-inch hammer mill at Streator Brick Co., Streator, Ill.

Summary

The method of securing the above data has been described. Table I shows all the essential data for each run that was secured with the exception of the detailed field notes on the weights of shale as fed, and the weights of each fineness in the sieve tests. Sample 42*d* was taken from the screened shale bin over the Streator Brick Company's brick machine and is included merely for the purpose of comparing the data from the dry pan and hammer mill discharge.

On all the curves the vertical ordinate corresponds to the per cent of material coarser than the opening corresponding to the abscissa of the same point. If any particular size opening is determined it is easy to see at a glance the amount of material that will pass this opening and the amount that will be retained. It should be understood that these curves are plotted from laboratory sieve tests and that these

openings do not correspond to the openings in a production screen. The curve in Fig. 5 shows the marked difference in grinding characteristics between the dry pan and hammer mill. It is possible that the dry pan would give more nearly the same shape of curve as the hammer mill if some way could be devised for instantly removing the fines as fast as they were produced.

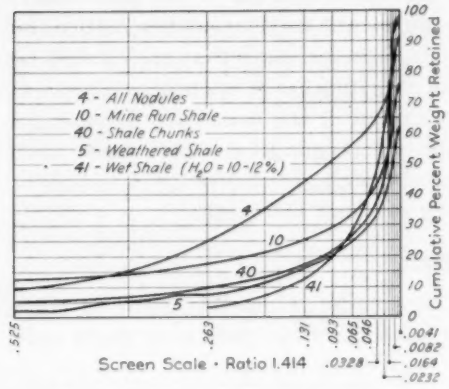
4 - All Nodules
10 - Mine Run Shale
40 - Shale Chunks
5 - Weathered Shale
41 - Wet Shale (H2O = 10-12%)
Cumulative Percent Weight Retained
Screen Scale - Ratio 1.414

FIG. 6.—All runs from hammer mill.

The curve in Fig. 6 demonstrates the ability of the hammer mill to reduce all sizes of feed in one operation. It can be seen that good grinding performance was obtained on practically all materials that were fed in in these runs.

It is well to mention here that at no time was it possible to feed the machine fast enough to keep the motor even reasonably well loaded; that is, in these tests we were unable to demonstrate the capacity of this machine because of the method used in feeding it. It was hardly practical to set up a mechanical feeder for the purpose of this test.

The curve in Fig. 7 is intended to show the result on the fineness of grinding of removing the hammers. It will be seen that either taking out alternate rows of hammers or taking alternate hammers out of each row considerably increases the coarseness of the discharge. It seemed that the most satisfactory operation was obtained with alternate hammers out of each row, since when all the hammers in alternate rows were removed occasionally very large chunks of material were passed by the machine.

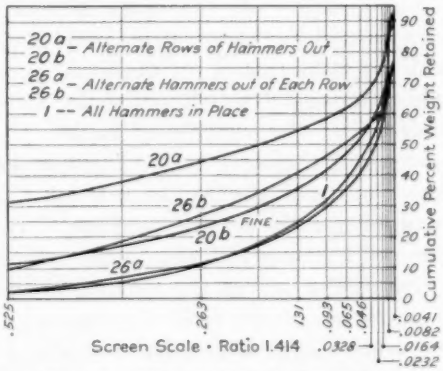
20a – Alternate Rows of Hammers Out
20b
26a – Alternate Hammers out of Each Row
26b
1 -- All Hammers in Place
FINE
Cumulative Percent Weight Retained
Screen Scale - Ratio 1.414

FIG. 7.—All runs from hammer mill.

It was found that with all hammers in, and with the small hammer circle of the machine being tested (30-inch diameter) that very large chunks would not feed down into the machine because the impact between successive hammers was so close together

that the chunk was kept in the air. Also, with all hammers in, the fineness of the grinding was greater than was considered necessary and it was thought that a saving in power consumed would result if the grinding was made only as fine as was necessary. These beliefs were all borne out by the data obtained.

The curve in Fig. 8 shows the result on power consumption of improper feeding. The data in run 35 was secured from one large chunk only, and this chunk was bounced around on top of the hammers for a total of 125 seconds. The great length of time and small weight of shale fed accounts for the high power consumption. This condition, of course, is unusual. At the same time if proper precautions are not taken to avoid it, it might easily be encountered in production operation.

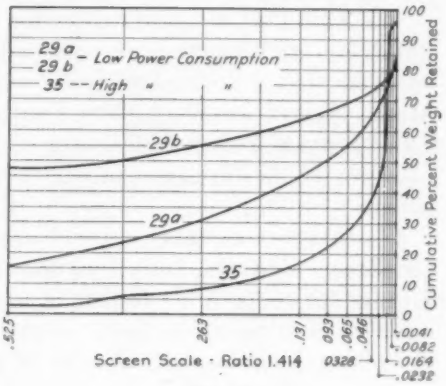

FIG. 8.

Figure 9 was taken looking down into the hopper of the machine tested and shows at the bottom of the picture the breaker roll and grinding plates. In immediate foreground can be seen the hammers and their mountings.

As a result of these tests it has been decided that to grind the large chunks and to secure a capacity sufficient for a production of 200,000 building brick in eight hours that a larger hammer mill than the one tested would be needed and has been provided. Its hammer circle is 40 inches in diameter. It is to be equipped with two fly wheels each weighing 2500 pounds, such that the total weight of the rotating system is approximately 7500 pounds. It will be mounted direct connected to the same 1200 speed, 100 h. p. motor. It will be fed with a 42-inch wide apron feeder capable of delivering up to 75 to 100 tons of feed per hour. This machine is equipped with screen bars to keep the large chunks in.

FIG. 9.

OGDEN ENGINEERING COMPANY,
OTTAWA, ILLINOIS

COMPARATIVE TESTS OF SOME AMERICAN AND GERMAN FIRECLAY BRICK[1]

By R. F. Geller and W. L. Pendergast

ABSTRACT

The Bureau of Standards has recently completed a short investigation comprising comparative tests of five brands of German-made brick and six brands of American-made brick. The results indicate that the Ge man-made brick are practically the equal of the American brick.

Introduction

The fact that a specification for German naval high temperature duty clay brick has been recommended requiring a softening point not less than that of cone number 34,[2] while the United States Government Master Specification[3] requires a softening point not less than that of cone 31, made it seem desirable to determine whether or not the average qualities of the foreign-made brick were actually as superior as indicated.

Advantage was taken of the opportunity offered by the visit of Dr. Steger and Dr. Endell to this country in the spring of 1925 to arrange for coöperative testing of fireclay brick made in Germany and America, and for an exchange of the results obtained. It was believed that these results would also be of general interest to manufacturers and users of fireclay refractories and that the comparative data of two laboratories would be of particular interest to those engaged in the testing of clay products.

In a conference with Drs. Steger and Endell it was brought out that the difference in softening point requirements could be accounted for partly by differences in the cones used and partly by the German method of preparing the test cone. A chip is broken or sawn from the sample brick and ground down to the size and shape of the standard cone; consequently it has the relatively coarse structure of the brick and would not soften as readily as if ground to pass an 80-mesh screen, as is done in this country.

Scope

Specimens of five brands of brick, representing the product of eastern and western Germany, were obtained from abroad. In exchange, samples of seven brands were sent to Dr. Endell by three coöperating companies; these samples represented the product of the New Jersey, Pennsylvania, and Kentucky districts.

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[1] Published by permission of the Director, Bureau of Standards, Department of Commerce. Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Refractories Division.) Received March 1, 1926.

[2] *Tonind. Ztg.*, **44**, 1097–98 (1920).

[3] Bur. Stand., *Circ.*, No. 299.

TABLE I

District represented	Lab. no. of brand	Method of manuf.	Size, inches av. of 5 specimens	Weight lbs.	Weight oz.	Chemical Composition SiO_2[a] %	Al_2O_3[b] %	Fe_2O_3[c] %	TiO_2[d] %
East. Germany	*A*	Stiff mud	9.7 x 4.7 x 2.5	8	5	54.9	39.8	2.0	1.9
	B	Hand made	9.8 x 4.8 x 2.5	7	15	60.6	33.9	2.2	1.3
	C	Hand made	9.6 x 4.5 x 2.6	7	7	59.3	34.5	2.0	2.0
West. Germany	*D*	Hand made	10.1 x 4.8 x 2.6	8	5	57.8	36.4	2.6	1.4
	E	Hand made	9.7 x 4.7 x 2.5	7	13	66.2	28.1	1.4	1.9
Av.				7	15	59.7	34.5	2.2	1.7
N. J.	*F*	Stiff mud	8.9 x 4.4 x 2.4	6	4	63.3	34.1	0.3	1.9
	G	Stiff mud	9.0 x 4.4 x 2.5	6	8	(75.8	20.5	1.4	2.1)[e]
Pa.	*H*	Dry press	8.8 x 4.4 x 2.4	7	1½	53.7	40.2	1.7	2.3
	I	Hand made	8.8 x 4.4 x 2.5	7	0	54.1	39.9	1.6	2.3
	J	Stiff mud	8.9 x 4.4 x 2.4	7	7	53.7	39.2	1.8	2.4
Ky.	*K*	Dry press	—		—	56.0	39.9	1.8	2.3
Av.				6	14	56.1	38.6	1.4	2.2

[a] Double dehydration
[b] (R_2O_3) Double precipitation
[c] Jones reductor
[d] Colorimetrically
[e] Not considered in average

TABLE II

Lab. no.	Load test[a] 1 specimen Deformation %	Endurance test Average 2 specimens[b] deflection in thirty secondths inch Deflection %	Remarks	Quenching test Average 5 specimens[b] Absorption after reheating %	Quenching test Number of quenchings to produce failure	Softening point in cones	Absorption as received Av. 5 specimens %
A	2.3	14	Slight fracture	10.7	24	32	10.6
B	5.9	15		14.5	16	32	16.6
C	8.1	10		14.8	8	29–30	16.3
D	2.5	6		12.1	19	32	15.2
E	7.4	18	Bad fracture	11.0	15	31	13.5
Av.	5.2	13		12.6	16		14.4
F	3.6	6		16.8	34	32	18.3
G	0.0	13	Bad fracture	17.2	2[c]	30	15.5
H	1.8	11		8.9	29	32	8.0
I	4.6	12		10.0	17	32–33	10.9
J	4.8	6		7.9	9	33	9.2
K	1.0	—		—	33	33	—
Av.	2.6	10		12.2	21		12.4

[a] Standard A. S. T. M. test for heavy duty brick, C 16-20
[b] For details of method see Bur. Stand., *Tech. Paper*, No. 279
[c] Siliceous type

The foreign brick, and brick of six of the American brands sent abroad, were analyzed chemically; the softening points were determined and they were subjected to the standard load test for high temperature duty brick, the quenching test, and the endurance test.[1]

Results

The results obtained at the Bureau are given in Tables I and II.

With the exception of the brick made by the stiff-mud method, the foreign product is rather irregular in shape, but is strong, with sharp corners, and having a structure comparable with that of domestic manufacture. The size of the foreign product is consistently larger and the average weight is greater by one pound and one ounce.

Excepting the highly siliceous open-firing New Jersey brick, *G*, the German brick average 3.6% higher in silica, 4.1% lower in alumina, 0.8% higher in iron (as Fe_2O_3) and 0.5% lower in titania. In view of the general impression that German brick are siliceous, it was surprising to find the chemical compositions so nearly identical.

The group averages (Table II) show the German brick to be slightly less resistant to deformation under load in both the standard A.S.T.M. test and the endurance test, also less resistant to failure in the quenching test and approximately one cone lower in refractoriness. The differences in absorption are believed to be of no significance. In fact, the group results lead to the conclusion that the German brick are so slightly lower in quality that they can be considered as practically the equal of the American brick.

TABLE III

Lab. no. of brand	Temp. at which deformation began °C	Temp. at which specimen had decreased 4% in length °C	Softening point in cones	Alumina (Al_2O_3) content %
A	1250	1380	33–34	39
C	1270	1390	30–31	35
F	1150	1390		
G	1200	1460		
H	1260	1440		
I(*a*)	—	—		
J	1220	1400		
K	1150	1490		

(*a*) Not tested; apparently because brick was so friable that a specimen core could not be drilled out.

Comparison with Results of Tests Made in Germany

A progress report received from Dr. Endell, dated Dec. 11, contained no complete data other than results for the American brands

[1] For descriptions of these tests see the *Transactions of the A.S.T.M.*, and Bur. Stand., *Tech. Paper*, No. 279.

and two German brands (*A* and *C*) obtained with a load test furnace described in a special leaflet of the Research Company for Refractories, Inc., Breite Strasse 3, Berlin-Steglitz. Since the tests were made on especially prepared specimens, under a load differing from that used in the A.S.T.M. Standard Test,[1] and the end point was taken as that temperature at which the specimen had decreased 4% in length, the results are not directly comparable. The data furnished by Dr. Endell are given in Table III.

Summary

Group results obtained on brick of five brands made in Germany and brick of six brands made in this country indicate that the German brick are so slightly lower in quality that they can be considered as practically the equal of the American brick.

[1] The load used was 2 kg. per sq. cm. A load of 25 lbs. per sq. in. is equivalent to 1.76 kg. per sq. cm.

THE ROLE OF SPECIFIC HEAT IN THE SELECTION OF REFRACTORIES[1]

By A. Ernest MacGee

ABSTRACT

A brief discussion of specific heats is given in which particular emphasis is placed upon its determination at high temperatures, the methods which have been used in the past for its determination, and the application of the values in the selection of refractories. The need of determining physical properties of brick which have been in service is pointed out.

History Joseph Black[2] was probably the first to illustrate the different capacities for heat of the same mass at different temperatures. It was in this connection that he originated the ice calorimeter which consists simply of two blocks of ice one of which is slightly hollowed out. In order to determine the specific heat of a substance by means of this apparatus, a weighed sample heated to the temperature in question is placed in the hollow of the one cake of ice and covered with the other. By noting the quantity of ice melted, it is a simple matter to calculate the number of calories of heat stored in the sample.

The work of Black was continued by Irvine[3] who was the first to publish a clear explanation disentangling the four entities, specific heat, mass, temperature change, and quantity of heat, when more than one was varied at a time. This work was conducted about 1770 and from then on the scientific world has had a clear conception of the phenomenon which enables different substances and the same substance at different temperatures to absorb different quantities of heat.

The work of Irvine was followed by that of Laplace and Lavoisier[4] who developed the ice calorimeter method to a fair degree of accuracy. Although Crawford[5] had probably been the first to use the method of mixtures, Dulong and Petit[6] developed it to a point where it could lay claim to scientific accuracy and made the first really reliable specific heat measurements. As a result of their determinations, they formulated their well known law.

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[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Refractories Division.)

[2] Lectures on the Elements of Chemistry, edited by J. Robinson, Philadelphia, 1807.

[3] Irvine, "Essays, Chiefly on Chemical Subjects," London, 1805.

[4] Laplace and Lavoisier, Memoirs de L'Academie de Science, 355 (1780). Ouevres de Lavoisier, **11**, 287, 725(1862).

[5] Crawford, "Experiments and Observations on Animal Heat." London, 1777–78; Philadelphia, 1787.

[6] Dulong and Petit, *Annales et de Physique*, **2** [7], **142**(1817). *Jour. Ecole Polytechnique*, **11**, 189 (1820). *Annales de Chemie et de Physique*, **2** [10], 395 (1819).

Definition By specific heat is meant "the quantity of heat necessary to cause a unit change of temperature in unit mass usually measured in C. G. S. units as calories per gram per degree centigrade." More simply stated: "Specific heat is the number of calories required from some external source to raise the temperature of one gram of material one degree centigrade."

Description Scarcely any two substances have exactly the same specific heat over any given temperature interval and the specific heat of most substances varies with the temperature. In the case of allotropic modifications of the same substance such as quartz and cristobalite, the form stable at the higher temperature generally has the greatest specific heat. Thus, cristobalite has a slightly higher specific heat than quartz. As a general statement, the specific heat of a substance decreases with the temperature, that is, more heat is required to heat a given substance (fire brick) from 100 to 101°C than from 900 to 901°C. However, the value ordinarily desired is not the specific heat at any particular temperature but the interval specific heat; that is, the average specific heat over a given temperature range of, say, 25 to 1200°C. Interval specific heat increases with increase of temperature; *i.e.*, the specific heat over the interval 25 to 500°C will ordinarily be less than over the interval 25 to 1000°C.

The specific heat of some substances may vary quite perceptibly over any given temperature range owing to the fact that thermal changes are taking place. If an endothermal process is taking place such as the conversion of alpha to beta quartz or the driving off of chemically bound water, the specific heat will be abnormally high. This is quite apparent when one recalls that in order to raise the material to the temperature in question, sufficient heat must be added not only to heat the material as such but, also, to supply heat for the heat absorbing process. On the other hand if an exothermal process is taking place such as the oxidation of sulphur or the thermal processes which clays undergo at about 950°C, the specific heat will be abnormally low. The specific heat over any given interval will, of course, depend upon the net result of all endothermal and exothermal processes which the material may undergo. In the case of many ceramic materials, such as the clays for example, these thermal processes are very intense and, by all means, must be taken into consideration in determining their specific heats. Ordinarily, fired materials undergo only slight thermal processes which can be disregarded in specific heat determinations.

Methods The determination of the interval specific heats of many ceramic materials is greatly complicated owing to the fact that they often undergo thermal processes on heating which are not reversed on cooling, such as the decomposition of carbonates, firing of

combustible matter, etc. That is, they do not evolve the same amount of heat on cooling as they absorb on heating. The procedures which have been employed in the past to determine the specific heat of a given material can be classified under one or more of the following general methods:

1. From calculations based upon the law of Dulong and Petit and which require no experimental determinations. This law states that the product of the specific heat and the atomic weight of the solid elements is constant, being approximately 6.4. However, it is not applicable to ceramic materials as the specific heat of the various materials changes with temperature sufficiently to invalidate it.

2. From data obtained by a method based on Newton's law of cooling, which states that the time taken by equal masses of substances under exactly identical conditions in cooling through equal ranges of temperature is directly proportional to their specific heats. This method is, at best, inaccurate and is not to be recommended.

3. From data obtained by measuring the electrical energy required to heat the sample to a given temperature—the current passing through the test piece. This method is, unfortunately, limited to conductors of the first class and is thereby inapplicable for measuring specific heats of ceramic materials.

4. From data obtained by measuring the electrical energy required to bring the material, contained in a calorimeter, to a given temperature. Navias, at the University of Illinois, used a modification of this method and gave to the scientific world for the first time accurate figures for the interval specific heats of materials which undergo irreversible thermal changes. The calorimetric methods give very accurate values but are expensive to construct and are, usually, quite complicated in their operation.

5. From data on heat required to bring the material to a given temperature as calculated from curves obtained by a differential thermal method. This method was worked out by Cohn in Germany and gives values which take into account all thermal changes. The method is rather simple and the apparatus relatively inexpensive but the values it gives are not as accurate as those obtained by the calorimetric methods.

6. From data obtained in a differential thermal method in which the temperatures attained by the sample and a reference substance are measured after a definite heat treatment. This method was worked out by MacGee at Ohio State University and gives values which include all thermal processes the material may undergo. However, the results are not as accurate as those obtained in the calorimetric methods. It should be pointed out here that these methods which account for all

thermal processes, irreversible as well as reversible, have given values for the interval specific heats of raw clay and green bodies which are fully one-third higher than the values formally accepted. Obviously, this means that our ceramic kilns have been and are operating at a considerably higher efficiency than has ordinarily been supposed.

7. From data obtained by the procedure known as the method of mixtures. This involves heating the weighed unknown to the temperature in question and allowing it to fall into a calorimeter. Thus the quantity of heat it contains at the time of dropping can be measured and its specific heat calculated. In this method (as well as in that based on Newton's law of cooling), it is assumed that the heat evolved on cooling is equal to that absorbed on heating. Therefore, this method is inapplicable for specific heat measurements where the material undergoes irreversible thermal changes. Fortunately, fired materials such as chrome brick, fire brick, etc., undergo no appreciable thermal changes on heating and most of the thermal changes which silica brick undergo on heating are reversed on cooling so that this method is applicable for determining specific heats for refractories. Owing to its relative accuracy, ease of manipulation, and relative inexpensiveness, this method is to be recommended for the determination of specific heats of fired refractories over the entire temperature range in question.

Part Played by Specific Heat

The part that specific heat plays, or should play, in the selection of refractories is of decidedly more importance than the average technical man considers. This is true because, until thermal equilibrium has been reached, the influence of heat conducted across the brick in causing a temperature rise is not determined by the conductivity solely, but by the heat capacity per unit volume of material—the greater the latter the smaller the temperature rise produced by a given quantity of heat. In all heating and cooling operations, it is the thermal diffusivity and not the thermal conductance with which one is principally concerned.

The thermal diffusivity, $d = K/c \cdot s$ in which, c = specific heat, s = specific gravity, K = thermal conductivity, and d = rise in temperature produced in one cubic centimeter of the substance by one calory flowing in one second through one square centimeter of a layer one centimeter thick, having a temperature difference of one degree centigrade between its faces.

Thus one sees that specific heat and specific gravity, as well as thermal conductivity, are of vital importance when one is considering the relative ease with which a given refractory can be heated or cooled.

For instance, assume equal thermal conductivities: The greater the specific heat and specific gravity of a brick the greater will be the

quantity of heat that can be stored but the longer it will take to heat it to any given temperature. On the other hand, the less the specific heat and specific gravity of the brick the less will be the quantity of heat that can be stored but the quicker it can be heated to any given temperature.

The following table shows the values obtained by Tadokoro[1] for various types of brick.

THERMAL DIFFUSIVITY OF VARIOUS BRICKS

Temperature	Magnesia	Chrome	Silica	Common red	Fire clay
200°C	6.57	5.55	4.90	2.25	2.80
300	5.47	5.71	5.25	2.08	2.95
400	4.91	5.99	5.68	1.94	3.59
500	4.71	6.01	5.41	1.85	3.96
600	4.39	5.79	5.35	1.56	3.69
700	4.14	5.45	5.29	1.44	3.39
800	3.85	5.10	5.48	1.32	3.69
900	3.73	4.77	5.41	1.23	4.02

The diffusivity of magnesia and common red bricks decreases with rise in temperature. For silica, fireclay, and chrome bricks, the diffusivity increases with the temperature. Hence, it is to be concluded that silica brick are most suited for installation of a reservoir of heat, the temperature of which is required to rise as quickly as possible when hot gases come into contact with them, and to cool quickly when cold gases come into contact with them. Also, it is to be concluded that fireclay brick are better heat insulators than silica brick. The conclusions drawn from these data are in harmony with the experiences of practical men in the plants.

Since the thermal diffusivity is greater the less the specific gravity, one might suppose that high porosity would be desired in a brick. In this connection, J. W. Mellor[2] has suggested that the heat insulating properties of pores will vanish at high temperatures. This is on account of the increase in importance of the radiation of heat across the pores with rise of temperature as compared with the conduction of heat through the solid material. The transmission of heat by radiation across a pore is, according to Stephan's law, proportional to the difference in the fourth power of the temperatures, whereas the conductivity in the solid material depends on simple temperature differences. However, it can be shown that the transmission of heat by radiation across the pores only becomes as great as that by conduction across the solid material at a temperature of about 3600°C. So that only at temperatures far above the melting points of refractories does the heat insulating effect of the pores vanish.

[1] Tadokoro, "On the Determination of the Thermal Conductivity, etc., "*The Science Reports of the Tohoku Imperial University*; 1st series, 10 (1921).

[2] J. W. Mellor, *Jour. Gas Lighting*, March 10, 1914.

In conclusion, I would say that there are very accurate values in the literature for the specific heats of practically all of the common refractories over the entire range, 20 to 1400°C. Although an adiabatic method is more or less impractical, it is doubtless, from a theoretical standpoint, the most desirable of all methods for ceramic materials. In order to determine interval specific heats by this method, one would heat an outer furnace without heat flow to or from an inner furnace containing the sample and measure the electrical energy required to bring the system to any temperature. If further interval specific heat values are desired for fired refractories, I would suggest the use of one of the modifications of the method of mixtures for determining the values over the entire temperature range, 20 to 1400°C.

I feel that it would be quite desirable to have an investigation conducted with the object of determining specific heat, specific gravity, and thermal conductivity on brick which have been actually in service for a considerable period of time. This is because the character of the brick changes with use.

Lord Hall, O. S. U.
Columbus, Ohio

RECENT FACTORY EXPERIENCE AND EXPERIMENTS IN DRYING TERRA COTTA[1]

By James R. Bowman

ABSTRACT

An attempt was made to determine by experiment the best conditions with respect to temperature, circulation of air, and its relative humidity, by which to obtain shorter drying time, a minimum of warpage, and cracking of the ware generally. Also, a very tender clay was given special study with the object of finding a set of drying conditions by which its extreme tendency to warp and crack would be reduced to a point that would permit practical use of this clay for terra cotta body. The drying time was reduced about 40% by increasing the steam pressure in the heating coils and apparently some showing made in reducing the tendency of the ware to warp and crack. A schedule of drying that gave satisfactory results with the tender clay was developed on an experimental scale, but could not be applied to the factory driers because of limitations in the heating and circulation equipment.

Introduction

During the past year the Midland Terra Cotta Company has been confronted with two problems in connection with the drying of terra cotta: (1) To increase the output of its three Carrier driers and at the same time minimize the warpage and cracking of the ware. (2) To determine whether it would be practicable to use, in regular practice, a certain clay which was available but which showed a strong tendency to warp and crack in drying.

Drier Practice at Time Work Was Started

The three driers which are identical in dimensions and equipment are 28 feet long, 13 feet wide and 10 feet high, inside dimensions. They are equipped with 6 sections of heating coils, each section having 56.5 square feet of radiating surface; automatic control valves for controlling admission of steam to the heating coils; and a steam spray device for raising the relative humidity, when desired. This steam spray was automatically controlled by a hygrostat. The fan for furnishing circulation of air is a Niagara duplex connoidal type, size $3\frac{1}{2}$, which is driven at 1085 r.p.m. and delivers about 4,000 cubic feet of air per minute under pressure of one inch.

As is probably the case with all Carrier driers of this type, the duct from the fan to drying chamber terminates in a header fitted with ejector nozzles so shaped and placed that the hot air emerging under a pressure of approximately one inch, has a sort of jet action and picks up other air, inducing a circulation within the drying chamber which is said to be several times as effective as it would be without the ejector action. It should be stated in this connection that these are the first

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Terra Cotta Division).

or among the first of the driers equipped by the Carrier Company for drying terra cotta and that they have since found by experience that better results can be obtained by arranging the ejector nozzles at the side, thus causing the direction of circulation to be crosswise the chamber, instead of lengthwise as is the case with our driers which have their ejector nozzles at the end. This should be taken into consideration in connection with the results obtained.

The housing of the heating system has an opening at its end opposite that where the fan is located for admission of fresh air when drying, and also two hinged doors at its side for additional fresh air for rapid cooling of the chamber of ware after drying has been completed. An opening to a chimney in the wall of the drier provides a means for the escape of moist air from the drying chamber.

The arrangement of the ducts and ejector nozzles is shown briefly in Fig. 1.

Operation, Early Practice

The usual practice was and is to load each of these chambers with from 14 to 17 tons of terra cotta, on pallets supported on legs.

It was customary to start a chamber with 10 pounds of steam on four of the sections of coils and with the fresh air damper open. The hygrostatically controlled steam spray was set for 65% relative humidity and actually held the humidity between 60 and 70% up to the time at which the dry bulb temperature in the chamber reached 125°F. At this point the spray was automatically shut off and 50 pounds of steam automatically turned into the remaining 2 sections of coils. The time required to reach this temperature was from 3 to 4 hours. This arrangement was left unchanged until the end of the drying period, which was 38 to 42 hours total drying time.

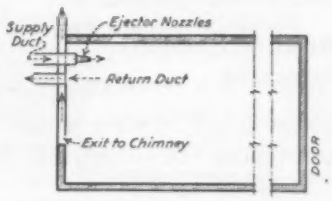

FIG. 1.—Showing arrangement of the supply duct, the ejector nozzles, the return duct, and the outlet to the chimney for escape of moist air, in the Carrier driers.

Under the above conditions the temperature inside the drying chamber rose at a fairly constant rate from that of ordinary room atmosphere to about 140°F in 8 hours. From then on the rate of rise was much slower, reaching a maximum of 165 to 170° at the finish.

The relative humidity started to drop immediately after the spray was stopped and went gradually from the maximum of about 65% to a minimum of 12 to 15% at the finish.

With this method of operation the drying time of the ware was, as stated above, from 38 to 42 hours. Some warping of the ware occurred and usually about 2% of it cracked. In some cases the cracks were

large and deep, and in others they were small, shallow, surface cracks, which seemed to be caused by condensation of water on the surface during the drying process.

Experiments Made with the Carrier Driers

A number of experiments were made with the driers, in each of which the original method of operation, as described above, was varied in some particular; the object was to find some set of conditions which would make possible a shorter drying time and also reduce the tendency of the ware to warp and crack.

Most of the experiments made were repeated a sufficient number of times to make the results definitely conclusive.

In each of these experiments the loss of weight of one piece of ware was determined by means of an ordinary platform scale located above the drying chamber. The test piece was suspended from the scale by a wire extending through a hole in the top of the chamber. A piece weighing about 75 pounds was selected for this purpose in each case.

A record of the temperature change in one piece of ware was obtained by means of a recording psychrometer, with its wet bulb buried in the piece. A wet and dry bulb thermometer set was used for determining relative humidities.

Relative Humidity Increased One set of experiments was based on the assumption, that by carrying a high relative humidity in the early stages, a relatively high temperature of ware would be attained and that this would result in shortening the subsequent drying period as well as reducing warpage and cracking.

Relative Humidity Decreased Another set was tried to determine the effect of carrying a lower relative humidity in the initial stage, so as to accomplish a reasonable amount of drying during this period, thereby leaving less work to be done after the stopping of the spray. One of the considerations in this case was the avoidance of fine cracks resulting from condensation on the ware.

Circulation Increased In order to obtain more rapid circulation of air in the drying chamber, the fan speed was increased from 1085 to 1200 r.p.m.

Regulation of Fresh Air Inlet An attempt to bring up the temperature rapidly was made by keeping the fresh air inlet closed during the steam spray period, then keeping it half open for 14 hours and finishing with it completely open.

Results of above Experiments None of the changes numerated above affected the final results to any important extent. The records obtained all seemed to point to the conclusion that what was needed was more heating capacity.

Use of Increased Steam Pressure

On the strength of the information obtained in the previous experiments, it was decided to use boiler pressure, 90 to 100 pounds, on the two high pressure sections of coils instead of 50 pounds. This caused a decided reduction in the time required to dry the ware, bringing it down from about 40 to about 34 hours which was a saving in time of about 15%. No change in the tendency of the ware to warp and crack could be detected.

This change had been tried out, initially, on only one of the three driers. The improvement seemed to justify making the same change on the other two and this was accordingly done.

Experiments with a Small Drier

Our experiments with the full size driers were subject to certain limitations. First of all some consideration had to be given to the question of safety to the ware in the drier; but the most serious limitatations were in the heating capacity and the air circulation. It was thought that better progress could be made and with less expense by doing a certain amount of experimental work on a small scale, with a drier in which we could raise temperatures as rapidly and as high as desired and in which a more vigorous circulation could be obtained.

An experimental drier was accordingly built for the purpose. The drying chamber was made of one-inch lumber, having inside dimensions 32 inches wide, 36 inches high and 48 inches long and lined with galvanized sheet iron. Its top was made removable to permit loading and unloading of the ware. The steam heating coils were arranged inside, at the bottom of the drying chamber, as was also a steam spray device. A small fan with electric motor attached was arranged at one end of the drier, near its top, and made connection with the drying chamber by a supply duct near the top of the chamber and a return duct near its bottom. The return duct contained a small vent for admission of fresh air to the system.

The drying chamber was equipped with a scale for measuring the loss in weight of a piece of ware; a psychrometer, which was used for measuring the temperature of the interior of a piece and a dry and wet bulb thermometer set for measuring relative humidity.

The drier with its equipment is illustrated briefly by Fig. 2.

The clay from which the ware was made for use in the tests was a coal measure clay, from Greene County, Southwestern, Ill. This clay which is available and offers a source of additional supply seemed to be suitable for terra cotta, with the exception of its strong tendency to warp and crack, which had resisted all attempts to dry safely in the Carrier driers.

It should be stated that during the time that the experiments on this tender clay were being conducted in the drier a slow drying test was also made, using the same kind of pieces as those used in the drier. This was done by putting several pieces on pallets on the floor of a room whose temperature was about 100°F and which contained no forced circulation of air and leaving them there until they were dry, which required 3 to 4 days' time. Under this treatment the amount of warpage was small and only one piece cracked.

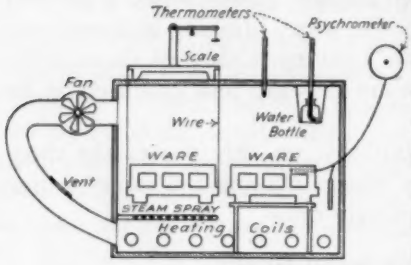

FIG. 2.—Showing arrangement of the equipment, the test apparatus, and the position of the ware, in the experimental drier.

It was assumed that if any set of conditions was found whereby this particular clay could be dried safely at a rate which would be practicable they would give equally as good results with most of the clays used in the manufacture of terra cotta.

In the experiments two pieces of ware were dried at each test. They were rather large base pieces, having dimensions $4\frac{3}{4} \times 17 \times 18$ inches, a form of piece which tends to give trouble by cracking when dried in the plant driers. They were taken immediately after they were dumped from the molds, finished, and the drying process started at once. Ordinarily this treatment would be considered severe, as in our usual practice it has been found essential to allow the ware to stiffen up somewhat before loading it into a drier.

The writer had found by previous experiments that the dry shrinkage of a piece of ware is complete when it has lost about 60% of its free water, which in our case is about 11% of the wet weight of the piece. This was found to be true of the clay used in these drying experiments and also of two other clays. The conclusion was made therefore, that during the time shrinkage is taking place the rate of drying should be controlled within certain limits, so as to make possible a more uniform rate of shrinkage throughout the piece, but when the shrinkage period in the drying has been completed, the danger of warping and cracking is passed and drying may be hastened from that point on to completion without injury to the ware.

The rate of drying during the shrinkage period was varied for different runs, in order to find the rate which was best suited to the safety of the ware. This was done by varying the relative humidity by means of the steam spray and noting the loss of weight every half hour, of a piece which was suspended by wires fastened to the scale on top of the

drier. A record was also kept of the vapor tension, vapor pressure difference, which is a criterion of the rate of evaporation. In each case when the ware had lost 11 to 12% in weight, (which required about 7 hours' time) the steam spray was stopped and the drying let take its course from then on to the finish.

It was thought that with complete recirculation, that is, with no opening for the admission of air to the system, evaporation from the test pieces would keep the humidity sufficiently high for good results, even with rapidly rising temperature. The first run was accordingly made without the use of a steam spray. The humidity did not go up as anticipated and the ware cracked badly. This may have been due, to some extent, to leakage of air into the apparatus but it seems probable that evaporation simply did not take place rapidly enough to compensate for the rapidly rising temperature.

Thereafter, the steam spray was used in increasing amounts, thereby raising the relative humidity and making a gradual improvement in the ware with respect to cracking, until a set of conditions was reached under which the ware could be dried with very little trouble from cracking. Cracking could not be eliminated altogether, however, until provision was made for admission of better circulation at the bottom part of the piece where it was protected to some extent by the drying pallet. This was done by perforating the pallet with holes and arranging a pipe to deliver a strong current of air under the pieces. With this equipment the ware could be dried free from cracks.

The best results were finally obtained as follows: after the ware was arranged in the drier and the equipment put in order the fan was started and run at room temperature for 2 to 3 hours by which time the ware had lost about 1% of its weight. Steam was then admitted to the heating coils and the dry bulb temperature in the drying chamber rose quite rapidly from that of the room to about 195°F in 4 hours. From then on until the ware was dry, which was from 12 to 14 hours total time, it rose constantly up to 210 to 215°F.

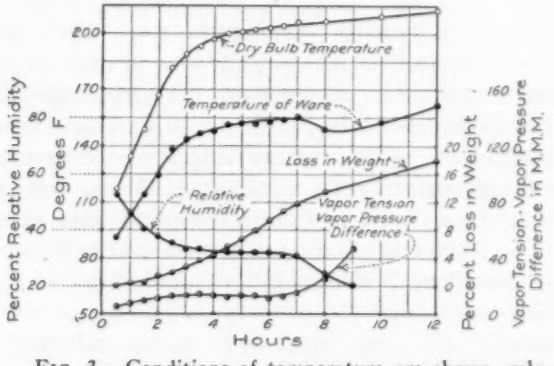

FIG. 3.—Conditions of temperature are shown, relative humidity, rate of drying, etc., with the experimental drier. This set of conditions gave satisfactory results with respect to the safety of ware which was made from a very tender clay.

By this procedure it was found possible to dry the test pieces in the time stated without cracking and with an amount of warpage considerably less than that which occurred with duplicate pieces dried in the plant driers. It should be stated, however, that the warpage was somewhat more than that which took place in similar pieces dried more slowly, on the regular factory pallets in a warm room.

Figure 3 shows the factors of temperature, loss in weight, relative humidity and vapor tension, vapor pressure difference, all plotted against time in hours. The set of conditions represented here in graphic form gave the most satisfactory results. It was quite definitely concluded, that the conditions for drying which were worked out with the experimental drier to give good results, would also give equally as good results on a plant scale. It was realized however, that the problem would be more difficult on a larger scale, because to get the proper circulation of air over all surfaces of the ware would be harder to accomplish in the case of a large quantity of it stacked together than it was in the case of two pieces in the small drier.

The decision was made, at any rate, to duplicate as nearly as possible in the Carrier driers, with their present equipment, the conditions of temperature and relative humidity by carrying steam pressure of 90 to 100 pounds in all of the 6 sections of heating coils during the total time of drying and by using the steam spray for a longer time in the initial stages than had been practiced previously.

Attempts to Duplicate Results of Experimental Drier in the Plant Driers

The clay used for making the ware which was dried when making these experiments was largely that in general use in our plant at that time. It was a coal measure clay from the Brazil district of southwestern Indiana. Its tendency to warp and crack in drying was probably not above the average of that of the various clays in common use in the manufacture of terra cotta. Also a few pieces made of the same tender clay that was used in the small drier were dried each time.

The ware was allowed to remain on the floor of the pressing shop for the usual length of time before loading it into the drier, after which the drier was loaded the usual way, except for the weight of ware which was smaller, being from 7 to 9 tons for each run. That quantity was not sufficient to fill the drier, so a wider space than usual was left at the front part of the drier and the required space of about 30 inches overhead and at the rear.

The pieces made of the tender clay and by the same mold as those used in the small drier, were placed, some of them near the front part of the stack of ware and some near the rear part. One piece was sus-

pended from the scale for measuring the loss of weight, also the psychrometer tube was imbeded in one of them for measuring its interior temperature rise.

The fan and steam spray were started working and boiler steam pressure of 90 to 100 pounds admitted immediately to all of the 6 sections of heating coils.

The relative humidity was kept regulated by means of the steam spray so as to allow practically no evaporation of water from the ware, as indicated by the scale during the first 3 to 4 hours. In fact the scale showed in most cases a gain in weight during the first hour or so, as may be seen by the "loss in weight curve," Fig. 4.

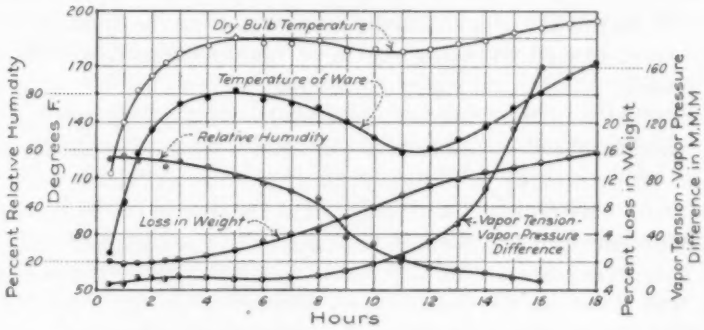

FIG. 4.—Showing conditions of temperature, relative humidity, rate of drying, etc., with the Carrier drier, when trying to duplicate there the results of the experimental drier. This set of conditions was not a duplicate of that obtained with the experimental drier, neither were the results satisfactory.

The object in checking drying during the first part of the run was to allow the temperature of the ware to go as high as possible, on the assumption that if the ware is at a relatively high temperature, drying may be allowed to proceed more rapidly and will at the same time be safer, because of a more rapid diffusion of water to the surface, thus maintaining a more uniform rate of shrinkage.

At the end of this 3 to 4 hours' heating-up period the relative humidity was made to drop somewhat more rapidly by reducing the steam spray and the drying thereby increased. This likewise caused a drop in the temperature of the ware.

After 3 to 4 hours' additional time the steam spray was stopped altogether and the drying allowed to take its own course from then on to the finish, which was about 18 hours' total time. This stopping of the spray caused a considerable drop in the relative humidity, a rapid increase in the vapor tension, vapor pressure difference and also a

further lowering of the temperature of the ware, all of which are indicative of a state of relatively rapid drying. Rapid drying at this time was further confirmed by an increase in the percentage loss in weight as indicated by the scale. The conditions of temperature, relative humidity, loss in weight, etc., may be seen in more detail in Fig. 4.

When these experiments were in progress a number of runs were made in which the above schedule was followed for the most part. A few variations in the fresh air supply were made, however, by closing or partly closing the fresh air vent during the first stages of the drying, none of which seemed to materially affect the results.

By using 7 to 9 tons of ware the drying time was reduced to about 18 hours. This reduction of the time necessary to dry the ware was partly due to the use of a smaller quantity and partly to an increase in temperature, caused by using steam of higher pressure on all of the heating coils for the total time of the run.

The condition of the ware with respect to warpage and cracking was not so good as it was in the case of the former method of slower drying at lower temperature. Practically all of the pieces which were made of the tender clay cracked, with the exception always of the piece which was suspended from the scale in each run. The ware which was made of the clay in regular use at the plant, which constituted most of that which was dried in the experiments showed a stronger tendency to crack also, but the cracks were small and shallow and seemed to be due to condensation of water vapor on the surface of the ware.

After studying the results of these experiments it was concluded that the results obtained in the small drier could not be duplicated in the regular plant driers for the reason that the temperature and circulation conditions could not be duplicated. The dry bulb temperature inside the drier was not nearly so high and to obtain as nearly uniform circulation of air over all exposed parts of the ware in case of a large quantity of it stacked together, was impossible with the present equipment and system of setting.

The primary cause of cracking in this case, seemed to be the lack of the proper circulation of air. A secondary cause was that of insufficient heating capacity to keep the temperature of the ware sufficiently high during the shrinkage period of the drying.

Further Experiments with the Carrier Driers and the Present Method of Operation

Having failed in the attempt to duplicate the conditions and results of the small drier in the Carrier driers the original method of operating the Carrier driers was resorted to, somewhat in detail, with the exception of the steam pressure in the heating coils. In this case the steam

pressure was 90 to 100 pounds, which as stated previously, was higher than that originally used.

The original practice of loading the driers to full capacity (14 to 17 tons), admitting steam to only part of the heating coils and at the same time using the steam spray for the first 3 to 4 hours of the run, then stopping the steam spray and turning steam into the rest of the heating coils for the rest of the run was given a trial.

The results seemed to show that this was the best method by which to operate. The time required to dry the ware in this way was found to be about 24 hours and the tendency to warp and crack was much less than it was in the case of the admission of high pressure steam to all of the coils at the beginning and seemed to be even less than that when using steam of lower pressure throughout the entire run, in which case the drying time was much longer.

Having obtained favorable results by the use of high pressure steam on all of the heating coils of one drier, the other two which were still running with steam of low pressure in part of their coils, were changed to high pressure also. Quite satisfactory results were obtained in this way with all three driers. For 18 runs in which a check was kept on conditions and results, the average drying time was 24 hours and the amount of ware cracked was .32% of that dried.

Obviously, these results were a decided improvement on those obtained in which the drying time was about 40 hours and the quantity of ware cracked about 2% of that dried.

While the above scheme of operating the driers gave very satisfactory results, as compared with the former practice, it was obvious that if the use of the steam spray in the initial stages of the drying could be eliminated, without injury to the ware, the method of operation would thereby be simplified. So drying without the use of the steam spray was given a trial and proved to be as satisfactory as with its use. Therefore, the three driers have been operated since without the use of the steam spray.

Briefly, the present procedure in drying is to load a drier to near its capacity (14 to 17 tons) with ware that has remained on the floor of the pressing shop for 24 hours after it was pressed. Steam is admitted to 2 sections of the heating coils, the fan started and the fresh air vent left open. After 3 to 4 hours' time, steam is admitted to the remaining 4 sections of heating coils and the side door next to the fan, in the housing of the heating coils, opened. Opening this door permits a certain amount of unheated, fresh air to be drawn into the drying chamber thereby preventing a sudden, rapid rise of temperature when steam is turned into the last 4 sections of heating coils. After 3 to 4 hours' additional time the side door is closed and the drying finished

without any further attention. Figure 5 shows the conditions in the drier during the drying process.

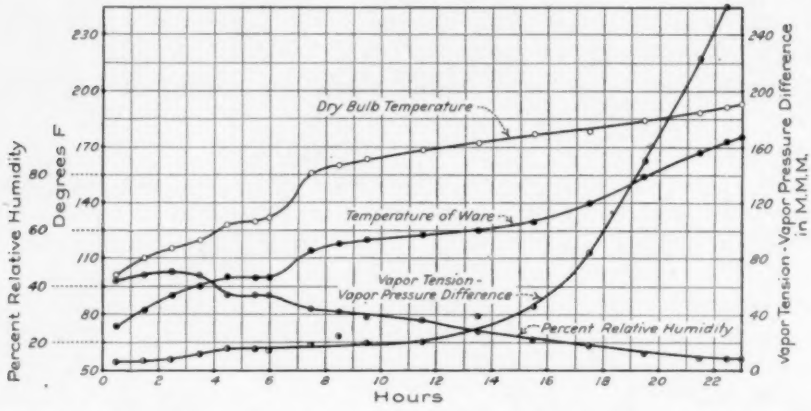

FIG. 5.—Showing conditions of temperature, relative humidity, etc., with the present method of operating the Carrier driers in which no steam spray is used. These conditions give good results.

Although this scheme works well with the clay which is in use at the plant at the present time, it is conceded that it probably would not be satisfactory with more tender clays.

General Conclusions

It seems quite evident from the results of the above experiments and from experience in general that terra cotta may be dried very rapidly and at the same time have its tendency to warp and crack minimized, if the conditions of temperature, relative humidity, and the circulation of air are properly controlled.

For rapid drying the heating capacity is of primary importance. Other conditions remaining constant, the rate of evaporation increases with rise of temperature and will proceed no faster than the rate of heat transfer from the heating medium to the ware. Therefore, if rapid drying is to be carried on, the heating capacity should be sufficient to maintain a relatively high temperature of the circulating air. This is very important if drying is to proceed rapidly while shrinkage is taking place, because of the more rapid diffusion of water from the interior of the ware to the surface with elevation in temperature. Those parts of the ware which are better exposed to the circulation of air, dry fastest and consequently shrink more rapidly than the parts which are less exposed, thereby creating a condition favorable to the tendency to warp and crack and any condition which hastens the

migration of water to those most rapidly drying parts of the surface; thus maintaining more uniformity in the distribution of water throughout the piece, is an aid to a more uniform rate of shrinkage.

Relative humidity is a controlling factor for the rate of evaporation and also for maintaining higher temperature of the ware. An increase in the relative humidity of the circulating air means an increase of the temperature of the ware, because of its slowing down evaporation which is a cooling action. Even with ware of relatively high temperature there is an upper limit to the rate at which drying can proceed safely during the shrinkage period. Therefore it is important to carry such relative humidity as will limit the drying to that rate.

A very important factor concerned with uniform and the consequent safe drying of the ware is that of the circulation of air. This is especially true when drying rapidly at high temperature. The impossibility of obtaining uniform circulation over all exposed surfaces of the ware in case of a relatively large quantity stacked comparatively close together in an enclosure is important. Were it possible to obtain uniform circulation over all exposed surfaces, including those of the webs and the interior, the rate of shrinkage throughout the piece would most likely be uniform. This much desired condition is impossible to obtain in practice however, and the only recourse is to approximate it as closely as possible.

Drying a very tender clay safely, at a rapid rate, in the small drier and not in the plant drier was due primarily to our being able to obtain more uniform circulation over all surfaces of the ware in the small drier. In the larger drier the temperature of the ware was not kept high enough. To keep the temperature of the ware sufficiently high in the larger drier it was necessary to carry higher humidity and this resulted in condensation which caused small surface cracks.

In plant practice we have found a very valuable aid to safe drying to be that of allowing the ware sufficient time to stiffen up somewhat before application of heat. This may be done by leaving it on the floor of the shop for a time after pressing before it is loaded or by circulating air of room temperature in the drier for a few hours before applying heat in the drying process. We practice the former method. It has been found that omission of this practice results in an increased tendency of the ware to warp and crack.

MIDLAND TERRA COTTA CO.
CICERO, ILLINOIS

NOTES ON GREEN SCUMMING[1]

By Earl R. Curry

ABSTRACT

A description of a green scum formed on brick made from a California clay. Analysis showed vanadium oxide as the principal colorant. Tests of scum prevention were made by adding various compounds to the green body or by dipping the finished piece into solutions of various salts. Several promising methods of scum prevention are indicated.

Introduction

By green scumming we refer to a greenish yellow to green efflorescence appearing on the surface of a fired fireclay body after moisture has been absorbed and evaporated from the ware.

Causes of Green Scumming Two explanations of this phenomena have been advanced: (1) It is sometimes said to be due to a growth of low organisms, an algae; or (2) it may be caused by colored soluble metallic salts in the body.

Seger[2] found in one case that the scum was caused by a chromium compound, and in another that the salt contained vanadium and molybdenum compounds.

C. W. Hill[3] has attributed the stain to ferrous salts.

Source of Clays The clays referred to in these notes are from the Sacramento Valley, California. They are mined near Lincoln and near Ione. The efflorescence-forming minerals seem widely and more or less uniformly distributed.

How the Scumming Develops

The terra cotta and light shades of brick on which the phenomena appears are fired to cone 4. After the fired ware has been set out in the open and has had the opportunity to absorb water and to dry, the scumming shows on the face from which the drying takes place. It is usually a greenish tinted yellow color later changing to a deep green color, although both colors *sometimes* appear side by side. An oxidizing agent such as hydrogen peroxide changes the green salt to a yellow color. Some of the ware, after periods of prolonged soaking and drying, will develop a heavy coating of scum which is readily soluble in hot water.

Analysis

Brick which had weathered a considerable period of time, and on which a heavy coating of green scum had appeared, were taken and the

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Terra Cotta Division.)

[2] Herman A. Seger, Collected Writings, **1**, pp. 381, 386.

[3] *Bull. Amer. Ceram. Soc.*, **1**, 51(1922).

easily soluble salt dissolved in hot distilled water. A sample was carefully prepared by concentrating this solution and filtering through ordinary laboratory filter paper. The solution was green and on evaporation to dryness yielded a green salt.

This sample was submitted to Smith Emery and Co., a commercial chemical laboratory of San Francisco, for qualitative analysis. Their report was as below:

Examination of green scum shows as follows, quantitative figures being given when complete separation was necessary to a careful analysis:

	Per cent		Per cent
Silica	Small amount	Cobalt oxide	Nil
Alumina	Small amount	Vanadium oxide (V_2O_5)	7.71
Iron oxide (Fe_2O_3)	0.15	Manganese	Trace
Arsenic	Nil	Magnesia	4.27
Copper	Nil	Potash (K_2O)	4.60
Lead	Nil	Soda (Na_2O)	5.01
Molybdic oxide (MoO_3)	1.65	Sulphuric anhydride (SO_3)	17.60
Nickel oxide	1.00		

Note: About one-half of sample is water of crystallization and organic matter, containing much nitrogen.

Interpretation of Analysis

This analysis indicates a mixture of several salts. Evidently there may be metavanadic acid, and sulphates of vanadium, nickel, and iron. Possibly vanadium molybdate or molybdenum vanadate may be present. Sodium and potassium vanadate may be a part of the mixture. There probably are vanadates and sulphates of sodium and potassium. It seems certain, however, from the analysis, that vanadium is the main element contributing to the discoloration.

Vanadium being one of the rarer elements the properties of but few of its compounds are definitely known. This fact makes the search for scum counteracting agents that much more difficult. As an example of the valencies with which vanadium may combine with other elements, its sodium compounds are here included.[1]

Sodium metavanadate	$NaVO_3$	Sodium tetravanadate	$Na_3HV_6O_{17}$
Sodium orthovanadate	Na_3VO_4	Sodium hexavanadate	$Na_2H_2V_6O_{17}$
Sodium pyrovanadate	$Na_4V_2O_7$		

The presence of nickel is *noteworthy* as thus being one of the scum-forming elements.

The presence of organic matter indicates an organic growth or algae. Probably the constitution of the soluble salt provides a favorable condition for this organic growth to develop.

[1] Thorpe, Dictionary of Applied Chemistry, **5**, p. 611, Longmans, Green and Co., New York.

Study of Methods for Preventing Green Scumming

There are two apparent methods of preventing the appearance of the efflorescence: (1) by adding some counteracting salt to the raw body, analogous to the well known use of barium carbonate, (2) by dipping the fired ware in some counteracting solution, where this is possible or economical.

1. Adding Salt

Use of Lead Discussing the first method, it appears that there are salts which at least hinder the development of greening. However, the discovery was made (it has been known for some time among some at least) that the use of a lead salt when added to a raw body hinders the development of scumming on the finished ware. Basic lead carbonate or white lead, being easily and more or less cheaply obtained, naturally comes to mind as the salt to use. Experiments have been run, in a laboratory way, to determine just how effectively lead serves as a preventative.

In making these tests, a terra cotta body was used. This body has an absorption of approximately 18%. The clay used was pulverized and an amount sufficiently large for the series of experiments was thoroughly mixed, so as to assure uniform distribution of the scum-forming minerals. Both the clay and, of course, the proportioned terra cotta body later developed the green discoloration. All trial bodies were thoroughly pugged so that whatever counteracting agent was employed, it would be distributed throughout the mass. Cones with a base diameter of about two inches and an altitude of about four inches were pressed from each mixture. These cones were slowly dried, fired at cone 4 in muffle terra cotta kilns, and then set in shallow enameled pans in about one-half inch of water. The water is thus drawn up through the porous cone by capillary attraction and evaporates from the upper surface, concentrating the majority of the scum on the point of the cone, and thus making identification easier.

It was soon discovered that if cones were dipped in a solution of C. P. HCl, the scum would rapidly turn to a reddish brown, and then gradually to a deep black-green color. Possibly this is due in the first color change to the formation of red vanadium tetrachloride, VCl_4, and brown pyrovanadic acid, $H_4V_2O_7$, and later to the formation of divanadyl tetrachloride, $(VO)_2\ Cl_4 5H_2O_7$, a dark green salt. Red molybdenum trichloride, $MoCl_3$, and brown molybdenum tetrachloride, $MoCl_4$, and to some extent the ferric chlorides, brown or black $FeCl_3$ or reddish yellow $FeCl_3 6H_2O$, may also enter into the first reaction. The formation of green nickel chloride, $NiCl_2 6H_2O$, may be part of the second reaction. This serves as a more or less delicate test for the

presence of the green salt, making it readily apparent on test pieces which would otherwise be classed as scum free. Where there is only a very small amount of scumming the first color change will not be noticeable, but the green discoloration will gradually appear.

In the experiments both the insoluble basic carbonate and the soluble acetate of lead were tried as scum preventatives. The following amounts of white lead were added to a definite weight of terra cotta body and made into cones as described above: 0.2, 0.4, 0.6, 0.8, 1.0, 1.6, and 3.2%. Lead acetate was likewise added in amounts of 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, and 3.2%. It is evident from these tests that the lead salts are increasingly effective as preventatives of green scum formation. However, even with the highest per cents used, a slight amount of scumming is noticeable after prolonged soaking and drying, and dipping of points of cones in HCl solution. It is also evident that white lead and lead acetate are about equal in hindering power. There is much less poison hazard, of course, in the use of white lead. In this reaction an insoluble lead vanadate is evidently formed. This agrees with Thorpe,[1] who states that the pyrovanadates of the heavy metals are mostly insoluble.

These laboratory tests of the use of lead salts in green scum control are also borne out by trial in a large way.

Use of Bismuth Referring to the last quotation from Thorpe's Dictionary of Applied Chemistry, it was thought that the salts of bismuth (atomic wt. of Bi = 208) might act similarly to lead. Tests using 0.2, 0.4, 0.6 and 1.6% of bismuth nitrate in same body as above, indicate that bismuth will also hinder the development of the green scum. With 1.6% of this salt, the cones after prolonged soaking, drying, and dipping in HCl solution, show a very slight amount of discoloration. The use of bismuth salts has not been tried in a larger scale, but has been experimented with only on a laboratory scale. The cost of the ordinary bismuth salts makes their use entirely prohibitive in a commercial way.

Use of Antimony and Zinc Antimony and zinc compounds have been tried in same manner as white lead and bismuth nitrate, but do not hinder scum development.

2. Dipping

The other method of prevention mentioned, by dipping individual pieces, is only applicable to certain types of ware.

In Potassium Carbonate Probably the salt most generally used is potassium carbonate. Brick dipped in a solution of this salt do not ordinarily green scum, but there seems to be a few

[1] *Loc. cit.*, p. 611.

cases where scumming has occurred. Whether the exceptions to the rule are due to the personal equation which enters into all manufacture, it is impossible to say.

In Barium Chloride

The same result has been accomplished in the laboratory using solutions of barium chloride, calcium chloride, and sodium carbonate. These solutions, however, in the same concentration as the potassium solution used, in turn tend to cause the formation of a white scum.

It would seem, however, that the use of potassium carbonate is open to objection on the ground that potassium sulphate, one of the products which results in the reaction, is itself soluble. No table at hand gives the solubility of vanadium carbonate. The ideal condition should be when insoluble products are formed in the chemical reaction taking place when dipping in a given solution. Apparently a solution of a soluble barium salt and an ammonium salt should fulfill these conditions. The barium will precipitate the soluble sulphates as insoluble barium sulphate. The ammonium salt, if the conditions are right, will precipitate the vanadium as white difficultly soluble ammonium metavanadate. The addition of barium chloride or barium hydroxide to a solution of the scum under investigation causes the formation of a white precipitate. A white precipitate forms when ammonium hydroxide is added. Also the solution loses its green color.

A solution of 30 grams barium chloride and 30 grams ammonium chloride to one gallon of water has so far proved effective in our tests. One-half of several brick known to develop scumming were dipped in the above solution. The brick were then set in a pan in about one-half inch of water. After several days the dipped half of each brick was free from green scumming while the undipped half scummed copiously. The same results have been observed with the use of a barium chloride, ammonium hydroxide solution. What the results will be when bricks so treated are set to weather through a winter season, have not yet been determined.

The Removal and Prevention of the Reappearance of Green Scumming Caused by Vanadium

A little laboratory work has been done on this problem, but so far no method has been developed which is satisfactory. The use of solutions acidified with sulphuric or hydrochloric acid, for cleaning, tend to form undesirable compounds and are to be avoided for this reason, and also because they attack the mortar joints of the walls to be cleaned. A potassium carbonate solution sprayed on a wall which has green scummed is said gradually to cause the green color to disappear.

Undoubtedly an understanding of the various methods of cleaning green stained walls, and preventing subsequent discoloration, would be a welcome addition to the knowledge of many of the industry.

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[1] The abbreviation (*C.A.*) at the end of an abstract indicates that the abstract was secured from *Chemical Abstracts* by coöperative agreement.

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Abrasives

Description of grading appliance. ANON. *Abrasive Ind.*, **7** [4], 122(1926).—A rather detailed description of C. E. Gillett's grading appliance is given. The principle of the instrument is to measure the frictional drag of a special tool on a grinding wheel; means are provided for measuring the wear on the tool. C. J. H

The lattice of carborundum type.—I. H. OTT. *Z. Krist.*, **62,** 201–17(1926); cf. *Ceram. Abs.*, 5 [3], 76(1926).—Trigonal SiC (Baumhauer type I) is rhombohedral, with $a = 3.095$ A. U. (same as types II and III) and $c = 37.95$ A. U. Unit cell contains 15 mols. C atoms are at 000, $00\frac{2}{15}$, $00\frac{6}{15}$, $00\frac{9}{15}$, $00\frac{13}{15}$; 5 more with same arrangement shifted through $-\frac{1}{3}, \frac{1}{3}, \frac{1}{3}$, and the remaining 5 shifted through $\frac{1}{3}, -\frac{1}{3}, \frac{2}{3}$. The Si atoms are similarly arranged, except that they are moved through 00p, where $p = \frac{1}{20}$. The same tetrahedral arrangement is found as in the other types. (*C. A.*)

Art

New accessions in the Classical Department. GISELA M. A. RICHTER. *Bull. Met. Mus. Art*, March, pp. 80–84(1926).—A number of rather small objects lately acquired by the Classical Department are shown in the Room of Recent Accessions. They cover all periods of classical art from early fifth century to Roman times and have a common charm and daintiness. One of the earliest pieces is a terra cotta relief of the first half of the fifth century B. C. It is decorated with a rare and interesting subject; Odysseus having his feet washed by his old nurse, Eurykleia. Returning home after twenty years' wandering no one recognizes him until the old nurse notices the scar of an old wound. It is this moment which the artist has chosen to represent. The youth and woman in the background are doubtless Telemachos and Penelope. The scene is indicated as taking place inside the house, by the four columns supporting the roof. Originally the relief was painted in bright colors; the white slip on which the colors were applied is still partly preserved. The figures have the splendid composure and detachment which is found in Greek art of the period. Two holes for fastening bear out the theory that reliefs of this type were used as decorative panels. Tanagra statuettes of very fine quality have become decidedly rare and there are two such pieces in this collection. One, a girl in a blue chiton and a pink mantle holding a fan; the other a young woman wrapped in a pink mantle. These pieces have the charm of perfect simplicity. The woman in the mantle is not a new find; it is published in the Catalog of the Lecuyer Collection, 1892 Plate 73, 3. Another piece from the same collection is a small terra cotta actor in female dress holding up his mantle to his face. It is a comical little figure and was perhaps used in a toy theater. Four small marble heads broken from figures are also among this collection and a marble vase from Athens is a rare piece. It

is in two parts, the body being shaped like that of a pyxis, the neck and mouth like those of an oinochoë. Athenian women had such stone vases among their toilet paraphernalia. A little steatite bowl from Crete comes as a gift from Joseph Brummer. It is of the Late Minoan period (second Millennium B. C.), lovely in form and finish. A. A. A.

The Parinirvana in Chinese pottery. S. C. Bosch Reitz. *Bull. Met. Mus. Art*, March, pp. 87–88 (1926).—The death of Gautama or Sakya-muni, the Buddha, in 483 B.C., has often been depicted, especially in well-known Japanese paintings. The dying Buddha is seen in the middle stretched out on a square sarcophagus-like pedestal; overhead the foliage of the trees is withering; his pupils and disciples are around him in great sorrow and all kinds of animals and birds are mourning for him. The Museum has acquired a group of Chinese pottery figures representing this scene. They are a kind of glazed colored pottery used for the architectural decoration of temples and palaces, very like the figures which stand on the carved eaves of the roofs; they come from a ruined Ming temple. The central figure, the dying Buddha, has three weeping disciples behind him while five others are grouped around. The group bears the date, 6th year of the reign of the Emperor Hung Chih (A.D. 1504) and further, the inscription that it was made by Hui Tai, a priest of the Zen sect on Mount Pan Ting. The workmanship is particularly good and it is a remarkable example of this kind of pottery, because it is dated and therefore serves as a guide to det. the period in which the Chinese roof tile figures and similar architectural pieces were made. A. A. A.

The Classical Collection: rearrangement and important accessions. Gisela M. A. Richter. *Bull. Met. Mus. Art*, Pt. 2, April, pp. 7–11 (1926).—There are some very important new acquisitions shown for the first time at the opening of the new wing K. There is a bronze hydria, a magnificent product of Greek craftsmanship, which has an inscription saying it was used as a prize at the games of the Argive Hera. One of the best examples of classical relief work is shown in the northern portion of the sculptural hall in Wing J. Two goddesses confronting each other are represented sprinkling incense on an incense burner. The piece is Roman in execution and not Greek. A red-figured "oinochoë," an exquisite example of Athenian pottery and decoration, is exhibited in the fifth room. The walls are so thin and the edges so sharp that it seems more like a metal than a clay vase, and the picture is drawn with very fine lines and with copious additions of white, pink, and gold so that it resembles a miniature painting more than a vase decoration. A dainty black-figured aryballos, another beautiful piece of Athenian pottery, is found in the third room. It dates from the middle of the sixth century B. C., the same period as the famous François vase in Florence. On the mouth is a spirited scene of pygmies fighting cranes, as many as 16 figures occupying a band about 5 inches long and half an inch high; while on the body is a decoration of crescents in four colors. Numerous explanatory inscriptions add to the interest. A. A. A.

Cement, Lime, and Plaster

Setting of hydraulic cements. M. Baykoff. *Compt. rend.*, **182,** 128–29 (1926); *Jour. Soc. Chem. Ind.*, **45B,** 193 (1926).—Le Chatelier's explanation of cement setting is considered insufficient. Setting is said to take place in 3 stages: (1) dissolution, during which the liquid is progressively satd. with the different sol. subs.; (2) "colloidation," corresponding with the initial set; (3) crystn., in which the gels are transformed into aggregates of large crystals, on account of the greater soly. of smaller crystals. This theory was verified by shaking Port. cement with water and analyzing the liquid from time to time. H. H. S.

Fused cement and sands containing humic acids. C. E. Wegmann. *Rev. Mat. Constr. Trav. Pub.*, **197,** 33–35 (1926).—A summary of a paper by A. F. Roscher-Lund in

Norwegian (*Teknisk ukeblad*, No. 35–37) describing compression tests made to det. the relative strengths of Port. and "fused" cements when mixed with sands contg. humic acids. The content of humic acid was detd. colorimetrically by comparing an ammoniacal extract of a sand with a stand. soln.

	Dry sand Weight per liter	Sp. gr.	Loss by washing %	Relative humic acid content
Good	1.759	2.70		0
Sands with humic acid			slight	
A	1.56	2.52	7.0	1.76
B	1.70	2.69	4.2	4.55
C	1.60	2.55	9.2	1.68
D	1.773	2.75	2.4	1.0

Mixtures in the propns. of 1 : 3, 1 : 5 and 1 : 10 were made and tested after setting in water, after 1, 2, 7, 28 and 48 hrs. Here the results for 1, 7 and 28 days will only be given.

		Compressive Strength Kg. per sq. cm. 1 day		7 days		28 days
	Proportion	Port.	Fused	Port.	Fused	Port.	Fused
Good sand	1 : 3	—	789	388	827	472	—
	1 : 5	—	652	255	718	335	—
	1 : 10	—	299	65	291	106	—
Sand *A*	1 : 3	—	478	0	556	8	660
	1 : 5	—	368	0	383	0	462
	1 : 10	—	116	0	163	9	148
Sand *B*	1 : 3	—	536	13	561	19	572
	1 : 5	—	414	8	430	17	495
	1 : 10	—	154	5	219	8	246
Sand *C*	1 : 3	—	386	8	376	38	391
	1 : 5	—	252	11	265	12	262
	1 : 10	—	81	7	98	7	100
Sand *D*	1 : 3	—	600	242	658	303	722
	1 : 5	—	444	39	500	161	566
	1 : 10	—	156	5	209	7	211

R-L. believes that the slightly lower strength for fused cements with the sands contg. humic acids are due to phys. and mech. factors, whereas the decided lowering with Port. cement and the same sands are due to chem. reactions. There is a large field for the use of fused cement in the Scandinavian mountains as a result of these findings.

L. N.

Franco-Belgian Association for Testing Materials. (Meeting of Jan. 22, 1926). H. C. *Rev. Mat. Constr. Trav. Pub.*, **198**, 86–89 (1926).—*Adherence of iron to plaster.* Mr. Anstett. Bars of soft steel, 16 mm. in diameter, were placed centrally in a mold, 10 cm. on a side, and filled with a good grade of plaster of the usual consistency (50% water). The cubes were removed from the mold after 48 hrs. and part of them were then kept in an oven at 30°, and the rest in humid air at 15°. Seven days after the pouring

of the plaster the specimens were tested by detg. the force necessary to pull out the steel rods, and the results calcd. for unit area (sq. cm.) of surface of contact. The rods were first treated in a number of ways: (1) iron rod with surface cleaned by fine emery paper, (2) iron rod completely rusted by long immersion in water, (3) iron rod painted the previous day with a coat of red lead paint, (4) iron rod covered for several days with a coat of red lead and completely dry at the time of casting the plaster, (5) iron rod covered with a cement slip and dry at the time of use.

Av. tangential adherence after 7 days of hardening

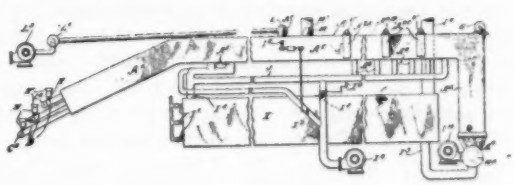
	No. of trials	In dry plaster	No. of trials	In humid plaster
(1) Bare iron	6	6.3	6	3.6
(2) Rusted iron	3	18.0	3	9.5
(3) Iron with fresh coat of red lead	3	4.2	3	2.6
(4) Iron with old coat of red lead	6	8.6	6	5.0
(5) Iron with cement layer	3	9.1	2	0.95

The values are consistently higher for the dry plaster than for the humid plaster. In both series the iron bars treated by rusting give the highest results. L. N.

Fireproofing properties of cement. B. C. COLLIER. *The Canadian Engineer*, **50** [13], 443–44 (1926).—Fire resist. of concrete is reduced by low heat resist. of aggregates, and failure to obtain intimate contact between cement and steel framework. A coating of cement and sand applied under press. to the steel framework before pouring the concrete is recommended. E. E. P.

PATENTS

Method of and apparatus for drying and calcining gypsum. CONRAD DRESSLER. U. S. 1,571,189, Feb. 2, 1926. App. for htg. mat. comprising a horizontally elongated htg. chamber terminating at one end in a depending portion, means for transporting mat. to be htd. through the body portion of said chamber, comprising a plurality of conveyor belts longitudinally disposed in said body portion and arranged one above another and being longitudinally displaced with respect to one another so that at the discharge end of the chamber each upper belt projects beyond the belt or belts beneath it and so that at their opposite ends each lower belt extends beyond the belt or belts above it.



Aluminous cements. C. PONTOPPIDAN and H. P. BONDE. Brit. 235,138, June 5, 1924. Cements with a high Al_2O_3 content are fired in a rotary kiln while protected from direct radiation from the flame, to prevent fusion. The flame may be surrounded by an annular jet of air or may be dild. by an excess of air, or a relatively cool and widely diffused flame such as that of producer gas may be used, or the kiln shell may be cooled at the point where the flame is formed. (*C. A.*)

Brick and cement containing colloidal silicic acid. NAAMLOOZE VENNOOTSCHAP KUNSTZANDSTEENFABRIEK "ARNOUD." Dutch 13,907, Dec. 15, 1925. Dune or river sand is treated with steam at 20–25 atm. press. until the surface of the grains is gelatinized (12–16 hrs.), then pressed in forms or used for the prepn. of mortar. The mass hardens on drying. (*C. A.*)

Enamels

Effects of blending ground coats. RUDOLPH WEIMER. *Ceram. Ind.*, **6** [4], 375 (1926).—A cover coat must have a lower fusion temp. than its ground coat. The m. p. and elasticity factor of the ground coat must be in harmony with the sheet metal and the cover coat. The ground coat must fuse to the enamel and the cover coat to the ground coat. The fluxes in the cover coat should be 2–3% higher than in the ground coat. The mill addition of clay and SnO_2 reduces the flux content of the cover coat. The metallic oxide of the ground coat must not be so high as to burn through the cover coat. It is best to have several ground coats of varying compn. which may be blended to have the desired properties. Zinc oxide gives an enamel frit resistancy, durability, strength, fire resist. and luster, and is claimed to be non-poisonous. R. E. G.

Researches in enameling and glazing. ANON. *Chem. Met. Eng.*, **33**, 167–68 (1926).—Lists the invest. now in progress at the Bur. of Stand. on enamels and glazes. M. E. M.

Iron-iron sulphide alloys. B. BOGITCH. *Compt. rend.*, **182**, 217–19 (1926); *Jour. Soc. Chem. Ind.*, **45B**, 194 (1926).—Pure Fe–FeS mixts., fused and protected from oxides by a layer of sodium silicate, do not form 2 liquid phases. Carbon causes sepn. of 2 layers, the upper of constant S content, the lower contg. an amt. of S dependent on the C content. An explanation of the desulphurizing of iron and steel is thus suggested. H. H. S.

Antimony enamels for cooking utensils. E. SVAGR. *Chem. Listy*, **20**, 21–24 (1926); *Jour. Soc. Chem. Ind.*, **45B**, 192 (1926).—Enamels contg. $NaSbO_3$ do not lose Sb by soln. in any organic acid of the strength met with in foodstuffs. They may be subjected to prolonged use for cooking purposes without ill effects. Antimonious compds. are more toxic. H. H. S.

PATENTS

Enameling metal. WESLEY J. BECK and JAMES A. AUPPERLE. U. S. 1,578,706, March 30, 1926. An article used for receiving a coating of enamel in the presence of heat, formed of open hearth or similar ingot iron refined to a stage where the manganese content is below .04% and degasification has taken place to the extent of leaving a substantially sound metal, and not to the extent of eliminating all of the oxide content, the said iron exhibiting under the microscope numerous well distributed spots of oxide in the surface and through the body thereof.

Process for treating ferrous metal to prevent corrosion. GEORGE D. BRECK. U. S. 1,580,647, April 13, 1926. The process of producing non-corrodible metal elements which contains the steps of htg. a slab or sheet of ferrous metal to a high temp. short of melting, covering the same with a superficial coating of a finely divided metallic subs. which consists largely of chromium, and immediately rolling said slab or sheet while it is still plastic to the desired shape and size whereby said metallic subs. is incorporated with the ferrous metal.

Glass

Thirty-five years in the glass industry. J. G. KAUFMANN. *Amer. Glass Rev.*, **45** [27], 17 (1926).—Recollections of the days when mach. was unheard of, its introduction into all branches of the indus., and other developments of by-gone years. F. G. J.

Progress in manufacture of glass reflected in history of Hamilton Co. W. H. NICHOLAS. *Amer. Glass Rev.*, **45** [27], 21 (1926).—A historical review of the J. T. & A. Hamilton Co., Pittsburgh, Pa., pioneer bottle manufacturers. F. G. J.

Colored glass and glass decoration. J. H. GARDINER. *Glass Worker*, **45** [24], 17 (1926).—Reprinted from *Glass*. I. Beginning with the early history of colored glass, which goes back to the times of the Pharaohs (?) the story is carried on to early cathedral stained glass. General rules for making this in imitation of the antique are given. II. A description of the methods of making colored glass, especially ruby glass, with the precautions that must be taken. A number of methods of control are given. F. G. J.

Annealing glass bulbs in a gas furnace. F. A. BECKER. *Glass Worker*, **45** [25], 17 (1926). Reprinted from *Fuels and Furs.*, March, 1926. F. G. J.

Test distribution of flame temperatures in furnaces. K. HESSE AND W. FRIEDMANN. *Glastechnische Ber.*, **3** [2], 46 (1925); *Glass Worker*, **45** [25], 24 (1926).—With a deficiency of air, combustion is so slow that the flame reaches down into the regenerators. As a rule combustion with a theoretical quantity of air results in incomplete combustion at the end of the fur. This is proved by gas anal. taken in the outlet port as follows: 15.3% CO_2, 1.2% O_2, 2.4% CO. With deficiency of air the anal. was 16.0% CO_2, 4.9% CO, 0.3% O_2. If 20–30% excess air is used there is unconsumed combustible in the outlet port and the flue gas anal. is 15.3% CO_2, 4.8% O_2. In checking these anal. it must be remembered that the glass mixt. gives off CO_2. In the adjustment of the character of the flame the following three points must be considered: (*a*) heat economy, (*b*) mtg. and fur. opern., and (*c*) chemistry of glass making. To obtain heat economy a slight excess of air should be used but this varies from case to case. In general, pot furs. require slow combustion, otherwise pots are damaged. Although tank furs. do not require the same care, they can be injured by extremely rapid combustion. Also rapid combustion results in unequal temps. No special flame adjustment is required if Na_2CO_3 is used as an alk. flux. If Na_2SO_4 is used by itself or in large quantities a reducing flame is necessary with about 45% CO in the downtakes. F. G. J.

Tyrolise 17th century glassware has been revived to retrieve Austrian fortunes. ANON. *Nat. Glass Budget*, **41** [48], 3 (1926).—Reprinted from the *Christian Science Monitor*, Feb. 19, 1926.—The glass factory in Kramsach, Tyrol, was founded in 1638 by the Duchess Claudia, one of the Medici family. Its rise and decline is traced. It is most famed for its "Butzenscheiben," curious glass panes like bulls eyes, of which one sees many in Berlin. The factory has been rebuilt since the war and is developing artistic glassware. It is probably the only factory in Europe where glass is "fuel blown" without recourse to molds. F. G. J.

Modern machinery in glass technology. QUASEBART. *Diamant*, **47** [31], 662–65 [32], 685–86 (1925).—The old methods of working glass by hand and some general facts about glass making are given. The blowing of glass is described in considerable detail. The Lubbers and Fourcault mach. are described in detail as to construction and operg. principles. The making of sheet glass with a Libbey-Owens mach. is discussed. Mach. for the making of large sheets of glass, the use of continuous leers for cooling the glass from 760 to 350°, grinding and polishing mach. are discussed. The greatly increased size of pieces which can now be handled by mach. is stressed. Mention is made of Ford's continuous plate glass plant. The kinds of ware which can be turned out with an Owens bottle mach. are described. The manuf. of elec. light bulbs by use of the Nestlake or Empire mach. in combination with the Bartford-Fairmont Feeder is discussed. Comparative figures on the mach. production of tubing, capillaries, etc., are given. Various minor questions are mentioned and answers given thereto. E. J. V.

Glassblowing machines in the hollow glass industry. HANS GOTZE. *Glas Industrie.* **34**, 2–4 (1926).—A description of the development and increasing use of glassblowing

mach. in the manuf. of hollow glassware, bottles, etc. The technique of operg. various types of mach. is discussed and a detailed account dealing with a Schiller mach. is given. E. J. V.

A contribution to the determination of modulus of rupture of glass and crystals. W. EWALD. *Glas Industrie*, **34**, 3–5 (1925).—An app. devised according to principles used by W. Voight is described and the method of using it to det. the modulus of rupture of glass and crystals outlined. Results of tests run on scratched and perfect prisms and crystals of rock salt, quartz, and glass are given. Results show that the mech. strength is greatly lowered by a scratch or a flaw in glass, but not to so great an extent in the case of rock salt and quartz. E. J. V.

The physical properties of glass in relation to its composition. I. The electrical conductivity of glasses. G. GEHLHOFF AND M. THOMAS. *Z. tech. Physik*, **6**, 544–54 (1925).—In the majority of glasses there is some relation between the condy., the viscosity and the tendency to corrosion by chemicals. The degree of dissocn. decreases with increasing temp. Data and curves show the effect on the condy. and the viscosity of a series of glasses, of the presence and amt. of CaO, BaO, B_2O_3, Fe_2O_3, PbO, MgO, ZnO, SiO_2, Al_2O_3, K_2O and Na_2O. (*C. A.*)

The influence of homogeneous neutral and of neutral zinc glass on the preservation of sterilized preparations. A reagent for the identification of suitable glass. E. BARO. *Boll. chim. farm.*, **64**, 673–77 (1925).—Inhomogeneous glasses contg. ZnO are attacked by water at 134°. Phenolphthalein is not suitable for the detection of decompn. in these glasses. A reliable reagent was found in a freshly prepd. 0.1% alc. hematoxylin soln. which indicates 0.0005 *N* NaOH by a purplish rose color appearing within 2 hrs. The color varies with the nature and concn. of the bases from purple to azure for BaO, CaO, ZnO, Al_2O_3 and their mixts., and persists 48 hrs. Glass for ampules should give a negative hematoxylin test within 24 hrs. after 1 hr.'s heating with distd. water at 2 atm. (*C. A.*)

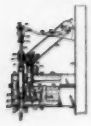
Properties of glass as an industrial material. E. BERGER. *Z. Ver. deut. Ing.*, **70**, 37–43, 129–32 (1926).—A general consideration of the characteristics and nature of glass is given. With data, mostly previously published, B. compares the phys. properties of glass with those of the common metals at normal temps. and with those of fused salts and amalgams at higher temps. While the variety of glass-forming elements is large, the chem. compn. of a glass must remain within fairly narrow limits to be workable, resistant to the action of water, and slow to crystallize. Röntgen-ray patterns indicate no definite mol. structure of pure glass. The change in complexes in glass during cooling is compared to that taking place in the passage of a colloid sol. to a gel. (*C. A.*)

BOOK

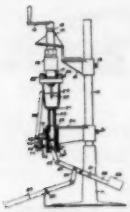
Early manufacture of glassware in the United States and Europe. ANON. *Glass Worker*, **45** [25], 17 (1926).—A long illustrated review of a book "Old Glass; European and American," by N. Hudson Moore, published by Frederick A. Stokes & Co., New York. Price $10.00. F. G. J.

PATENTS

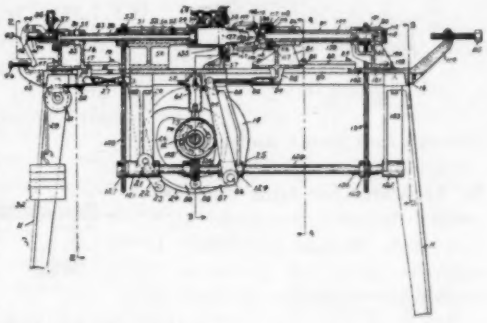
Glass feeder. LEONARD D. SOUBIER. U. S. 1,571,215, Feb. 2, 1926. The combination of a container for molten glass having an outlet opening in the floor thereof, a vertically reciprocating plunger in line with said opening, and means operable to successively register measured quantities of glass with said outlet opening, said means comprising a horizontally rotatable member having a series of pockets formed therein.



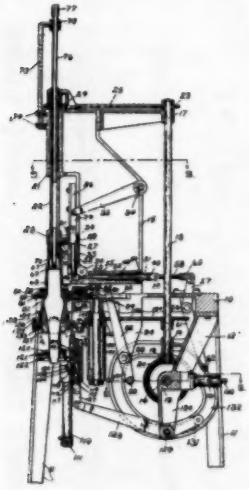
Method of and apparatus for forming glass tubing. LEONARD D. SOUBIER. U. S. 1,571,216, Feb. 2, 1926. In a tube forming device, the combination of a container for molten glass having an outlet opening in the bottom thereof, a forming device projecting vertically downward into the glass and through said opening, and a blow pipe disposed within said forming device and protruding below the forming device in position to be engaged by the issuing glass and thereby assist in imparting a tubular formation to the glass.



Method and apparatus for firing off glass. ERNEST C. SCHRADER. U. S. 1,578,098, March 23, 1926. The process which consists in impinging a flame upon glass along substantially the entire length of a line where severance is desired, maintaining the flame until severance of the glass, at such intensity that severance occurs without mat. deformation of the glass, and, while the severed edge is in the condition in which it is left by said severance, playing a flame simultaneously across substantially the entire length of the severed edge at a short distance therefrom and fire-finishing the same.

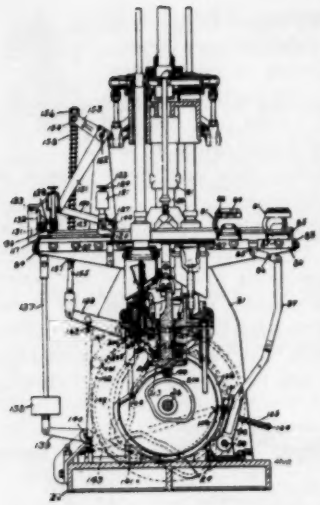


Process and apparatus for firing off glassware. ALVAH C. PARKER. U. S. 1,577,654, March 23, 1926. In app. for severing glass articles, a holder adapted to support an article from one end, a guide adapted to be positioned in close proximity to but normally out of engagement therewith outside of the other end of the article, and a burner adapted to apply a melting flame across the glass between the holder and guide. The process of firing off glass articles, which consists in applying to the glass along a line of desired severance a flame sufficiently intense to melt the glass and produce a severed edge along said line and, after said edge is produced, applying thereto a less intense flame to fire-finish the same.



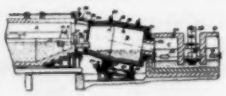
Method of and apparatus for firing off glassware. ALVAH C. PARKER. U. S. 1,577,655, March 23, 1926. In a glass severing device, a chuck, a burner in position to apply a melting-off flame to a glass article in the chuck, automatic means to vary the intensity of the flame, and synchronized automatic means for moving the chuck a slight distance away from the burner at a predetermined time during a period of intensified flame.

Automatic firing-off machine. ALVAH C. PARKER. U. S. 1,577,656, March 23, 1926. In glass working app., a vertically reciprocable chuck, a horizontally movable charging table having an article holder, and automatic means to reciprocate the table and thereby

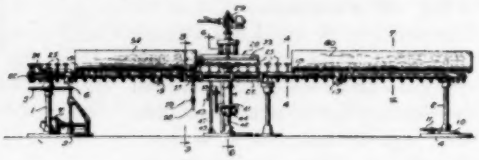


move the holder between a position in alignment with the chuck and a position at one side thereof.

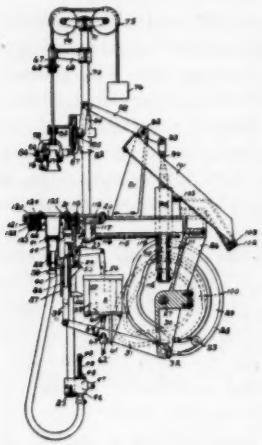
Process and apparatus for refining glass. WALTER O. AMSLER. U. S. 1,577,602, March 23, 1926. The process which consists in mtg. glass, introducing the molten glass into one end of a refining pool, refining the glass in the pool while rolling it about the longitudinal axis of the pool, and discharging the refined glass from the other end of the pool.

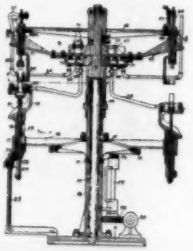


Apparatus for glazing edges of glassware. ALBERT BREAKENRIDGE KNIGHT. U. S. 1,577,581, March 23, 1926. A device of the character described comprising a prehtg. hood, means for htg. said hood, a ht.-retaining hood in alignment therewith and spaced therefrom, a conveyor adapted to move articles of glassware through said hoods, and a burner mounted between said hoods.

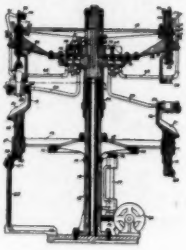


Apparatus for firing off glassware. ALVAH C. PARKER. U. S. 1,577,538, March 23, 1926. In app. for firing off glassware, a burner, a vertically reciprocable article carrier beneath the burner, and automatic means whereby an article is held in position on the carrier when the carrier is raised and is released when the carrier is lowered.





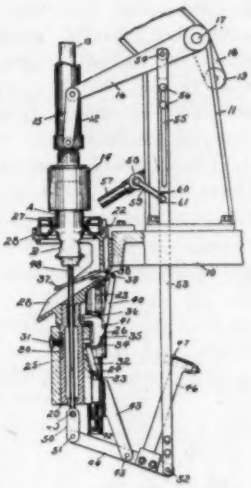
Method of and apparatus for severing glass. ERNEST C. SCHRADER. U. S. 1,577,543, March 23, 1926. A method of making glass articles, comprising blowing an article with a bead between the point of its attachment to the blow iron and the line of severance of the moil, utilizing the bead to apply stretching strain to said line of severance, and melting the glass along said line while the strain is being applied.



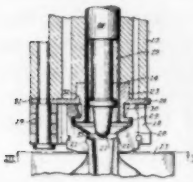
Apparatus for severing glass. ALVAH C. PARKER and CARL W. SCHREIBER. U. S. 1,577,536, March 23, 1926. App. for severing glass articles having forms of rotation, comprising means to support such an article, means to move the support in a closed path, an annular burner, and means to move the burner into position about the proposed

line of severance of an article in the support and move the burner with the support until the glass is melted along said line.

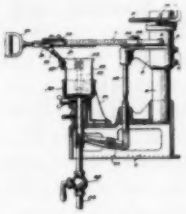
Apparatus for firing off glass. ALVAH C. PARKER. U. S. 1,577,537, March 23, 1926. In an app. for severing glass, a melting-off burner, a holder adapted to hold a glass article with its point of desired severance exposed to a flame from the burner, and automatic means operable upon the completion of a severance to increase the distance between the burner and holder and means to stop said increase at a fraction of an inch.



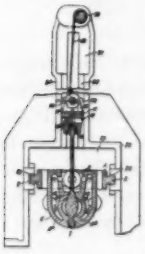
Machine for blowing glass articles. ALBERT N. CRAMER. U. S. 1,578,400, March 30, 1926. The combination of a mold comprising arms hinged to swing about a common axis and a thimble comprising separable sections carried respectively by said arms, an adapter arranged to be surrounded by the thimble when the mold is closed, said adapter having a supporting surface in a plane perpendicular to said axis, said thimble sections being formed to engage said supporting surface and thereby support the thimble sections during their opening and closing movements.



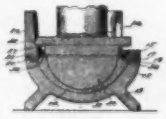
Apparatus for shaping glass articles. DAVID E. GRAY, HARRY R. BOALS, and JAMES BAILEY. U. S. 1,578,427 March 30, 1926. A glass shaping mach. comprising, in combination, ware retaining means, means for htg. the ware, a mold shiftable with respect to said ware retaining means, and laterally operable means for giving the ware the shape of the mold.



Manufacture of glassware. AUGUST KADOW. U. S. 1,578,442, March 30, 1926. The method of forming glassware, which consists in gathering from a source of supply a quantity of molten glass into a gathering member, removing the charged gathering member from the source of supply, holding one portion of the glass in the gathering member and applying a stretching pull to another portion of the glass to draw it in predetd. form from the gathering member.

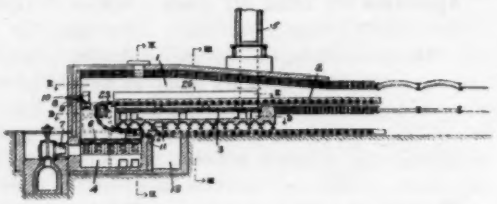


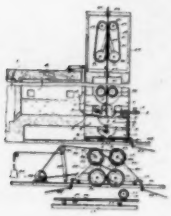
Method of pressing glass. STATES LEE LEBBY. U. S. 1,578,448, March 30, 1926. The method of preventing "sucks" in a pressed glass blank which comprises confining the shrinkage of the blank to a zone having unpressed walls and forming an optically non-essential portion of the blank.



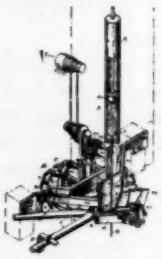
Leer for glassware and other articles. WALTER O. AMSLER. U. S. 1,678,792, March 30, 1926. In annealing app. an elongate horizontally extending chamber, the floor of said chamber being formed in a plurality of sections arranged at different levels, conveying means entering the chamber between the said floor sections and then advancing above the upper floor section,

and means for causing a stream of hot gases to flow externally of said floor structure, first beneath the lower floor section and then beneath the upper floor section. In annealing app. an elongate, horizontally extending chamber, means for htg. the floor of the chamber, a horizontally extending conveyor movable longitudinally within the chamber and at an interval above the floor and at an interval from the side walls of the chamber, and a shield extending parallel with and at an interval from the side walls of the chamber and extending from above to a level lower than the level of the conveyor.



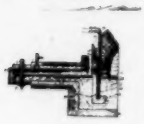


Glass-making machine. GEORGE A. SHIELDS. U. S. 1,578,926, March 30, 1926. In a glass mach. a flow chamber including a trough for receiving molten glass, a drawing chamber above the flow chamber, a supplemental chamber below the flow chamber, an elevating mech. mounted above the drawing chamber, said drawing chamber being in communication with the housing to permit sheet glass to be drawn from the drawing chamber for engagement with the elevating mech., said trough and supplemental chamber including separable sections for simultaneous movement away from each other to permit glass to flow in a downward direction from the trough and through the supplemental chamber.

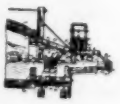


Machine and process for preparing quartz. LEVI B. MILLER. U. S. 1,579,019, March 30, 1926. In a mach. for cutting plastic quartz, a cutter, means for squirting the plastic quartz through an opening into operative relation with respect to the cutter for cutting purposes, means for seizing a length of the plastic quartz before the cutting opern. is performed, said cutter adapted for cutting the seized length from the squirted plastic quartz, and means for advancing the cut lengths of quartz beyond the cutter.

Water-cooled bridge. ROBERT GOOD. U. S. 1,579,353, April 6, 1926. A glass fur. including an individual bridge, said bridge having a pocket therein, and said bridge also having means to permit the flow of glass from the mtg. tank to the pocket and vice versa, a cooler adapted to be inserted in said pocket, said cooler comprising a hollow metallic member and water inlet and outlet pipes associated with said hollow member, the water inlet pipe extending to a point adjacent the bottom of the hollow member.

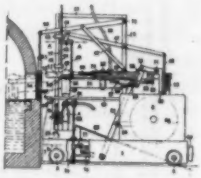


Individual bridge wall for flow spouts. GLEN E. HENNING. U. S. 1,579,364, April 6, 1926. In a glass fur., the combination of a bridgeless tank, a flow spout communicating therewith, and an individual bridge wall provided in said flow spout.

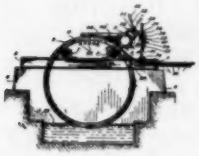


Automatic machine for manufacturing blown-glass articles. EMILE ROIRANT. U. S. 1,579,396, April 6, 1926. An automatic mach. for the mech. manuf. of blown glass articles comprising: a rough-shaping mold, means for imparting a horizontal displacement to said mold, means for giving this mold an

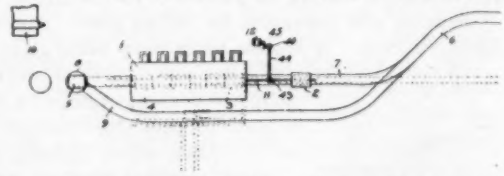
ascending and descending movement at one of the ends of its rectilinear course, a finishing mold, a ring or collar mold, means for alternately bringing the ring mold into coöperation with the rough-shaping mold for the formation of the parison or preliminary mass of glass, and with the finishing mold for the conveyance of the said mass to the latter, a blowing bell, and means for bringing this bell to the finishing mold after the departure of the ring mold on delivery of the parison to the said finishing mold.



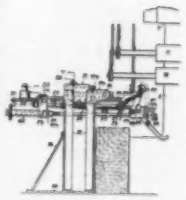
Apparatus for making sheet glass. LEE SHOWERS. U. S. 1,579,666, April 6, 1926. In combination in app. for making sheet glass, a casting table in the form of an annular shell of large diameter, roller means for supporting said shell for rotation, a driven sizing roll in opposition to the periphery of the shell positioned so as to provide between the shell and roll a pocket for receiving the molten glass to be rolled, end walls for the said pocket, and a runway for receiving the ribbon or sheet of glass formed between the shell and sizing roll.



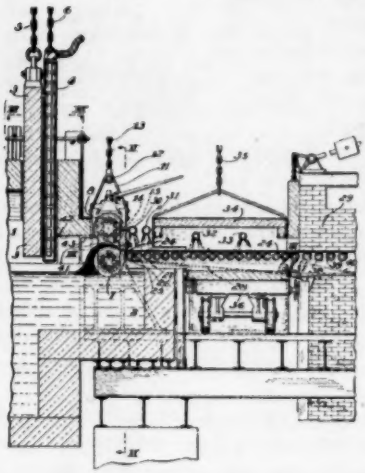
Apparatus for making plate glass. ALBERT E. EVANS. U. S. 1,580,122, April 13, 1926. In combination in app. for handling and treating pots contg. molten glass preliminary to casting the glass into plates, which comprises, a tunnel fur. having a track therethrough, a series of cars on the track for carrying the pots, a moving device for the cars extending longitudinally of the fur. engaging means on such device adapted to engage the car next to the outlet end of the fur. and also a car located outside the entrance end of the fur. but adjacent thereto, and means for reciprocating said device so that on the forward movement thereof, said car next the outlet end of the fur. is moved outside of and away from the fur. and said car adjacent the entrance is moved into the fur., thereby moving all of the other cars in the fur. ahead one car length. In combination in app. for handling and treating pots contg. molten glass preliminary to casting the glass into plates, which comprises, a tunnel fur. having a track therethrough and a passageway longitudinally of its bottom opening upwardly, a series of cars on the track for carrying the pots, a moving device for the cars extending longitudinally of the passageway, means extending upwardly from said device for engaging the cars, conduit means also extending longitudinally of the passageway, and a means for circulating a cooling fluid through said conduit means.



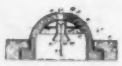
Edge-holding device for sheet-glass machines. JOHN H. FOX. U. S. 1,580,128, April 13, 1926. In combination with app. for drawing a glass sheet from a molten bath, means for preventing inward movement of the edge of the sheet comprising a pair of fingers spaced apart so that they will straddle the edge of the sheet, and mech. for moving said fingers at intervals downward along the edge of the sheet and into the tapering base thereof to thin it and then back from such position along substantially the same path.



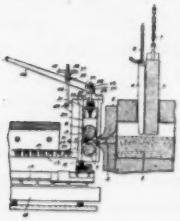
Apparatus for making plate glass. FREDERICK GELSTHARP. U. S. 1,580,130, April 13, 1926. In combination, a glass tank having a forehearth or extension having an open top, a pair of horizontally driven and cooled sizing rolls arranged one above the other in said open top with the lower roll partially immersed in the molten glass in the forehearth, and a glass receiving bed extending laterally from a point adjacent the pass between the rolls for carrying away the glass which is formed.



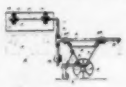
Apparatus for drawing sheet glass. ROBERT A. MILLER, JR. U. S. 1,580,150, April 13, 1926. In glass drawing app. employing a glass bath from which a sheet of glass is to be drawn, a refrac. member provided with a slot lying in the glass, a metal member having a slot portion lying in the bath above the slot in the refrac. member with the sides of said slot portion, over which the sides of the glass sheet are drawn, roughened, and means for cooling the portion of the metal slot member in contact with the glass.



Process and apparatus for rolling glass. GROVER C. OAKES. U. S. 1,580,156, April 13, 1926. A process for making plate glass which consists in flowing it continuously from a body of molten glass between a pair of driven sizing rolls, and periodically sepg. the rolls to permit a body of glass to pass therethrough of a thickness in excess of that of the ribbon which is being produced.

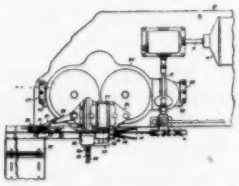


Glass-cylinder-handling truck. URIAH O. WRIGHT and CHARLES H. WRIGHT. U. S. 1,580,188, April 13, 1926. In combination in a truck for carrying glass cylinder sections, a body provided with wheels, a horizontal operg. shaft journalled for rotation in the body, a lifting crank arm carried by the shaft and adapted to have its free end inserted into the cylinder sections, means for counterweighting the crank arm, and a handle for turning said shaft.



Process of making fibrous material. CARL HERING. U. S. 1,580,199, April 13, 1926. The process which comprises forming a bed of quartz, forming an arc adjacent to said bed, and supporting a globule of quartz fused by said arc in solid quartz of said bed.

Glass-severing apparatus. CARL A. BROWN. U. S. 1,580,809, April 13, 1926. The combination with a traction means for causing glass cane or tubing to travel in a substantially horizontal direction, of a severing means comprising a cutting wheel and rotating means therefor, a support for said severing means and rotating means for said support, said parts being mounted and arranged so that a simple rotating of said supporting means causes said cutting wheel to be brought into and out of the path of travel of said cane or tubing while maintaining said cutting wheel always in substantially the same plane and to sever predetd. lengths therefrom.



Heavy Clay Products

Automatic manufacture of brick as seen in Europe. EDWARD BURKHALTER. *Clay worker*, **85** [3], 203 (1926).—The Keller system for the automatic manuf. of brick, is described. The clay column from the brick mach. is cut by an automatic cutting mach. The cutting opern. is timed by the rate of movement of the clay column in passing over a belt. The brick are automatically dropped onto pallets, whose movements are also timed by the moving clay column. Each loaded pallet is carried on automatically to the conveyor which operates to the elevator. Only one man is required at the brick mach., to supply pallets. The elevator carries the pallets to the floor above the kilns, where the brick are dried by waste heat. The dry brick are taken by transfer cars to the kiln setters. In this system the brick are not touched by human hands until they reached the kiln for setting. This means a min. of defective green brick. R. E. G.

Our Belgian competitiors. PETRUS LANGELAAN. *Brick and Clay Rec.*, **68** [6], 450–51 (1926).—L. describes the brick indus. in Belgium. The best brick, which are now being imported into New York, come from the Boone District, which is 15 kilometers south of Antwerp. These brick have a crushing strength of from 1000 to 1500 lbs. per sq. cm. Most of the plants are equipped with modern machinery. R. E. G.

Lamination in the clay column. A. HIELSCHER. *Brick and Clay Rec.*, **68** [7], 546–47 (1926).—H. claims *round* and *S* shaped cracks are two different kinds of lamination in brick. The *S* shaped cracks are caused by the pugging shaft of the auger, and the *round* shaped cracks (structures), by the blades or knives of the auger shafts. Both kinds of cracks may occur in the same brick. The following methods have been successfully used in overcoming laminations in the clay column: (1) An addition of sand or grog to all clays which are fat or soapy. (2) The prepn. of clay in a soft state. The unequal press. in the auger barrel is easier to equalize with soft clay than with stiff clay. (3) The head of the auger barrel may be lengthened. The risk of laminations is much lower as the distance between the die and the last blade is longer. (4) A "lamination destroyer" is described. These, however, retard the speed of the clay column and increase the power costs. R. E. G.

Shall prison brick compete with that made by free labor? ANON. *Manuf. in Canada*, **1** [3], 36 (1926).—Ontario brick makers are confronted with competition of the product of the prison brick and tile plant near Mimico, Ont., and have protested against the use of prison-made brick in a city bldg. on city property. This is due to the proposed use of these brick in the Ontario Govt. Bldg. at the Canadian National Exhibition, and several hospitals. E. J. V.

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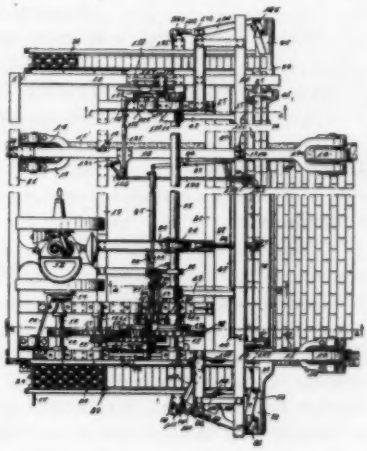
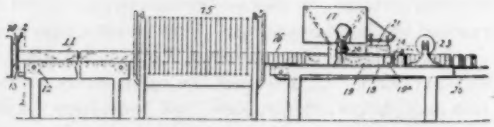
Machine for laying brick paving and the like. HALVER R. STRAIGHT. U. S. 1,571,386, Feb. 2, 1926. A brick laying mach. comprising a frame, means for supporting said frame transversely above a road bed, means for adjusting said supporting means to and from each other to accommodate road beds of different widths, a feeding hopper supported at one end of said main frame, means for delivering bricks from said

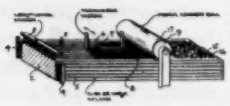


hopper to said road bed, in transversely arranged rows, and means for adjusting the last said means so that the length of the said transversely arranged rows of brick may be varied to meet road beds of various widths.

Building wall. JAMES CECIL MCDOUGALL. U. S. 1,571,285, Feb. 2, 1926. A hollow wall constructed of brick comprising 3 or more parallel brick partitions spaced from one another, vertically spaced bonding courses connecting each pair of adjacent partitions and extending the full length of the latter, the bonding courses of adjacent series being staggered vertically with relation to each other so that no joint between the partitions extends from one side of the wall to the other.

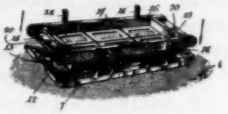
Process of forming face brick. SPENCER M. DUTY. U. S. 1,578,409, March 30, 1926. The process of producing face brick, which comprises forming a brick body of wet plastic mat., applying to the surface thereof relatively dry and finely divided mat. having plastic qualities, and firing the bricks so as to cause a uniform and substantially homogeneous structure between the body and surfacing mat.

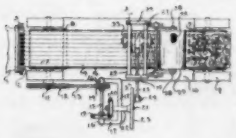




Process for producing rough-texture brick. WILLIS B. NEHER. U. S. 1,580,153, April 13, 1926. The hereindescribed process for the production of a rough text. brick, which consists in breaking up the face of the brick column by intersecting score lines into irregularly disposed raised patches of the column mat., rolling these raised patches to flatten them, and cutting the column into bricks.

Apparatus for the manufacture of rough-texture brick. WILLIS B. NEHER. U.S. 1,580,154, April 13, 1926. In a brick mach. mech. for longitudinally scoring a column of brick mat. a mech. for transversely scoring a longitudinally scored face of the column, and presser mech. to flatten down the doubly scored face of the column.





Process of manufacturing rough texture brick from soft mud and apparatus therefor. NEWTON A. MEYER. U. S. 1,580,519. A process of mfg. rough text. brick consisting in casting a slab of soft mud brick mat. in an undivided mold, depositing said slab on a base, inserting in said slab, while plastic, a cutting frame which divides the slab into a plurality of bricks having a rough text. surface, inverting the base, slab and frame collectively, and successively withdrawing said base and frame from the slab.

Refractories

Service requirements for plastic refractories. HUGH E. WEIGHTMAN. *Bull. Amer. Ceram. Soc.*, **5** [4], 210–13 (1926).—A general discussion of service requirements of plastic refracs. is given, stressing the necessary qualities required. The deficiencies in these mats. are named. Prices of plastic refracs. are exorbitant and a reduction thereof would greatly increase the use of them. Suggested requirements in plastic refracs. to meet service requirements are: increased mech. strength by better grading of grog and use of better bonding plastic clay; elimination of an excess of ganister and sol.

silicates; flinty structure on fracture of molded and fired sample by avoiding sandy and rounded off particles; the body should vitrify to a glassy structure to not more than ¼ in. E. J. V.

Discussion of "The thermal expansion of refractories." M. C. Booze. *Bull. Amer. Ceram. Soc.*, **5** [4], 215–19 (1926).—B. states that some of the conclusions drawn by Norton are not supported by sufficient evidence to have as general application as implied, and others are in disagreement to known facts. He enumerates these and gives results of other work which is in disagreement, going into considerable detail therein. N. replies, explaining some of B.'s misinterpretations in his criticism. E. J. V.

Canada's steel industy in history.—II. Anon. *Manuf. in Canada*, **1** [3], 11–13 (1926).—The opern. of early blast fur. in Ontario under difficulties which caused shut downs is mentioned. The development of the Steel Company of Canada through the successful promotion of several small companies which were amalgamated from time to time is traced. This company is probably the largest steel manuf. in Can. E. J. V.

Importance of refractory tests.—III. M. C. Booze. *Fuels and Fur.*, **4** [4], 425 (1926). This is part III of a series of articles on the above subject, and treats of the action of slags and fluxes on refracs. and effects of various constituents, limitation and value of slagging tests and expansion and contraction of refractories. The action of slags and fluxes on refractories is the most important cause of failure in a large number of indus. fur. The important factors are the compn. of the slag, compn. of the refrac. mat., temp., rate of slag renewal, fur. atmosphere, structure, density, and permeability of the refractory. Four methods for testing the resist. of refrac. to slag action are described and their relative values explained. Both permanent and temporary expansion of refrac. mats. are discussed. Contraction is caused by the formation of a glass within the structure or by the condensation of the particles of the mats. themselves. Permanent expansion is not as frequent as is permanent contraction. There are two kinds of permanent expansion: (1) that caused by overfiring and is brought about by the evolution of gas and the formation of a vessicular structure, and (2) that known as "secondary" expansion which is not reversible and is found on some first quality fire brick. The exact cause of this latter has not been detd.; it is not related to overfiring. It is prevented from taking place by loads as low as 1.5 lbs. per sq. in. and not objectionable. The property of silica brick to take on a permanent expansion is mentioned and the causes of this discussed. The importance in considering permanent expansion of refrac. in fur. design is pointed out and the values of the various kinds of refrac. are given. R. M. K.

Refractory lining for lime kilns. Berthold Block. *Feuerfest*, **1** [12], 125 (1926).—Discusses the fluxing action of lime on the fire brick lining and its thermal condy. and expansion. Care in erection must be taken to use only mortar as well as bricks of basic compn. Very thin joints should be used and the whole lining thoroughly dried (4–8 wks.) before it is used. F. A. W.

Notes on standard specifications for refractories. L. Litinsky. *Feuerfest*, **2** [1], 1 (1926).—Confusion in present classification of refrac. products points to the necessity of standardizing not only the shapes but properties and testing methods also. The principal properties of interest are as follows: (1) m. p., (2) chem. compn., (3) mech. strength, (4) s. p., under load, (5) vol. change, (6) thermal condy., (7) sp. ht., (8) resist. to quenching, (9) resist. to chem. action, (10) density and sp. gr., (11) imperviousness to gases, (12) color, (13) structure, (14) accuracy of shape. These properties are of varying importance in the different applications of refracs. and the importance of the larger organizations of consumers such as the glass mfrs., steel industry, etc., interesting themselves in standardization is stressed. F. A. W.

Refractories for the open-hearth. L. S. LONGENECKER. *Iron Age*, **116**, 1735–38 (1925).—Conclusions drawn from a study of failure of magnesite brick are that: too soft firing causes failure; the kiln firing temp. is all-important; the modulus of rupture is the best means for the consumer to gage the firing; and the brick is greatly weakened by the use of a lumpy nonuniformly ground mix. Tentative specif. are given. The chem. anal. specified is: MgO, over 82%; CaO, under 5%; SiO_2, under 7%; Fe_2O_3, under 8%; Al_2O_3, under 3% and $Fe_2O_3+AL_2O_3$, under 9%. (*C. A.*)

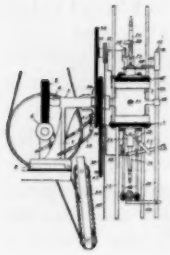
United States government master specifications for plastic fire-clay refractories. ANON. Bur. Standards, *Circ.*, No. 297, 5 pp. (1925). (*C. A.*)

Use of zirconia as a refractory. R. K. *Rev. chim. ind.*, **35**, 14–16 (1926).—Brief outline of the manuf. of refrac. ZrO_2 crucibles. (*C. A.*)

Refractories at Mellon Institute. M. C. BOOZE. *Iron Age*, **117**, 479–81 (1926).—A list of publications of the refrac. fellowship is included. (*C. A.*)

Occurrence and commercial purification of graphite. W. LANDGRAEBER. *Brennstoff-Chem.*, **6**, 355–56 (1925).—Deposits in Europe and N. America are discussed briefly. The most important deposit commercially is in Ceylon, mainly because of its purity and easy workability. Purification of raw graphite was formerly effected by grinding and sieving, which resulted in considerable loss of fines. This is now recovered by flotation methods. (*C. A.*)

PATENTS

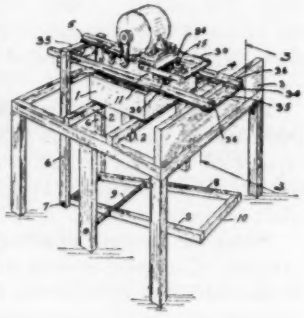


Method of and apparatus for the manufacture of hollow ware from refractory mineral substances. CYRIL C. SCHNUR. U. S. 1,571,607, Feb. 2, 1926. A method of mfg. hollow ware from refrac. mineral subs., consisting in first fusing a quantity of the subs. into a tubular billet with an elec. arc, then extinguishing the arc and then drawing the fused mat. into an elongated tubular form.

Porous article of rutile and method of making the same. SIMON J. LUBOWSKY. U. S. 1,578,900, March 30, 1926. A shaped, refrac. chem.-resisting article, formed of crushed rutile, the particles of which are bound together to form a porous body.

Terra Cotta

PATENT



Terra-cotta tooling machine. ERNEST S. NIESTRADT. U. S. 1,580,155, April 13, 1926. In a device for tooling terra cotta molds, in combination, a supporting framework, means carried by said framework for supporting a terra cotta mold, a supporting member extending upwardly from the forward end of the framework, a pair of spaced, parallel guides forming a guideway having its forward end supported on said supporting member, a support for the rear end of said guideway, means for raising and lowering the last named support, and a tooling mach. slidable in said guideway.

White Wares

Bureau of Standards perfects precise method for measuring thermal dilatation of glazed ware. ANON. *Nat. Glass Budget*, **41** [48], 7 (1926).—G. E. Merritt and C. G. Peters of the Bur. Stand. have developed a method for measuring thermal expansivities

of glazes and bodies. Measurements on samples produced according to the old method gave diametrically opposite and misleading indications. It is hoped that the application of this method will cause a large reduction in the losses on glazed wares. The method is not given. F. G. J.

Modern pottery equipment. G. L. MONTGOMERY. *Chem. Met. Eng.*, **33**, 142–46 (1926).—A detailed description of the new factory of Thomas Maddock's Sons Co., with many photographs. M. E. M.

PATENT

Process of making a vitrified composition. FRANÇOIS RICHARD. U. S. 1,579,032, March 30, 1926. The process of making a vitrified insulator which consists in mixing a natural clay contg. about 56% of silica, about 20% of alumina, about 8% of sesquioxide of iron, and alkalis, with enough water to make a plastic mass, molding to desired shape, htg. to about 900°F and then raising the temp. to not over 1600°F; and then maintaining the temp. at not over 1600°F whereby to wholly vitrify the mass and then allowing to cool.

Equipment and Apparatus

Observations on the development and use of steel drying equipment in the ceramic industry. H. M. SCHAAB. *Bull. Amer. Ceram. Soc.*, **5** [4], 206–10 (1926).—Depletion of timber resources has made it necessary to look for a substitute mat. for making drying boards. Higher first cost has been one objection which is being overcome by the decreased maintenance cost and other advantages. The lowest priced suitable mat. is steel. Its advantages over wood are: equal strength in all directions, rendering possible the giving to it of any shape; resist. to warping under ordinary conditions; rigid connections by welding; smoother surface; and the fact that it conducts heat instead of being an insulator. Improved methods of protecting it against corrosion overcome the objection due to the aversion of the clay worker to iron oxide. Steel boards were first used in the cement brick and block, concrete tile, and silica fire brick industries. The next logical step was to use them in terra cotta plants. The advantages of steel boards in the sewer pipe and conduit industry are enumerated and discussed, as are possible uses in other branches of the ceram. indus. E. J. V.

A new fireproof metal casting. EMIL SCHÜZ. *Feuerungsechnik*, **14** [11], 127 (1926).—Compn. tests are described and illustrated showing the superiority of the new mat. "Alferon" for grate bars, damper plates, hardening boxes, etc., in contrast to ordinary cast iron and steel. When exposed to high temps. the surface oxidation forms a thin protective coating on the metal which does not flake off. Dampers out of ordinary C. I. which were entirely destroyed after 4 month's service when made of "Alferon" were unaffected after 7 month's service. Similar results were obtd. with grate bars. The process is comparatively simple and inexpensive and patent has been applied for by Meier & Weichelt Co., Leipzig-Lindenau. F. A. W.

Oil engines drive Georgia brick plant. ANON. *Power*, **63** [13], 481 (1926).—A description is given of the oil engines generating power at the Georgie White Brick Co. C. J. H.

The Bureau of Mines Orsat apparatus for gas analyses. A. C. FIELDNER, G. W. JONES, AND W. F. HOLBROOK. Bur. of Mines, *Tech. Paper*, **320**, 18 pp. (1925).—The app. described and illustrated differs from the ordinary Orsat app., principally in the compensation for changes of temp. and press. by means of an auxiliary compensating tube, included in the water jacket surrounding the buret. If C_2H_6 is detd., a Cu oxide-tube, elec.-heated, replaces the Cu_2Cl_2 tube and the CO is detd. with the H_2 by com-

bustion. The prepn. of absorbents, notes on oper., and combustion data of the commonly occurring gases, vapors and solids are shown. (*C. A.*)

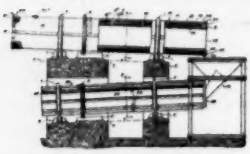
Measurement of humidity in closed spaces. J. ALFRED EWING, R. T. GLAZEBROOK AND EZER GRIFFITHS. *Dept. Sci. Ind. Research, Food Investigation Board Special Report*, No. 8. 54 pp. (1925).—Account of a study of existing types of hygrometers, together with a description of novel methods and instruments designed to meet special requirements. Cannot be satisfactorily abstracted. (*C. A.*)

Potentiometer for routine determinations. C. W. G. HETTERSCHIJ. *Chem. Weekblad*, **23**, 3–4 (1926).—The app. devised for the use of lab. technicians has the advantage of cheapness, simplicity, direct p_H reading, and sturdiness. The measuring range is p_H 3.5–8.5. A rheostat and a resist. unit for rough and fine regulation are arranged on both sides of the circular constant resis. unit, subdivided into equal manganin coils with 100 dials. Thus the p_H difference between 2 dials is 0.05. The accuracy can be further increased by taking the av. of 2 galvanometer readings. (*C. A.*)

Black body for optical pyrometer calibration. H. S. ROBERTS. *Jour. Optical Soc. Am.*, **10**, 723–24 (1925).—Details are given for the construction of a black body for use in the calibration of optical pyrometers from the fusion point of a metal. A small piece of the metal is htd. to fusion at the bottom of a graphite or porcelain tube of suitable shape, and the "matching" is done as the metal is observed to melt. The advantages of the procedure are that it gives a direct detn. of the temp. of the black body and that very little of the stand. metal is required. (*C. A.*)

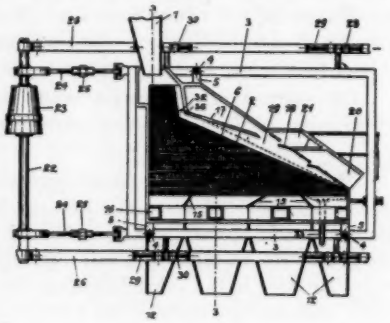
PATENTS

Means for separating, washing, and discharging comminuted solid material immersed in liquids. CARL H. NORDELL. U. S. 1,570,854, Jan. 26, 1926. In combination with a device for sepg., washing and discharging comminuted solid mat. immersed in liquid, a check valve, a piston and a connection between said check valve and piston, causing said piston and valve to move in unison.

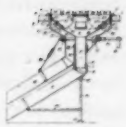


Tabular processing apparatus. HOMER L. RANK and HURXTHAL F. FREASE. U. S. 1,579,030, March 30, 1926. A tubular process app. including an outer tubular shell, an inner tubular shell, a chamber between the shells, means closing the ends of the chamber, and a tubular trussed structure in the chamber spacing and maintaining the shells.

Apparatus for sorting granular materials of different specific gravities. PAUL F. A. C. ANDRÉ. U. S. 1,579,993, April 6, 1926. An app. for sorting granular mats. and ores, comprising an inclined sloping sieve, longitudinal ribs provided upon the upper surface of the sieve, means for longitudinally vibrating said sieve in a direction substantially parallel to the ribs thereon, air blast means at the underside of the sieve for subjecting the mats. to be sorted, in addition to its horizontal displacement, to an ascendant motion, a dead zone formed on the sieve in the region where the heaviest particles of mat. are discharged, and means for varying the area of the zone during opern. of the app.



Grain blending and distributing apparatus. RICHARD C. STONE. U. S. 1,580,176, April 13, 1926. The combination of a plurality of adjustable grain-spouts, a distributing receptacle through which the grain is delivered to said adjustable spouts, said receptacle having inlets for grain from different sources, and means supported by and located at the discharge end of said distributing receptacle whereby the grain passing into any of said inlets may be selectively directed into any of said spouts.



Kilns, Furnaces, Fuels, and Combustion

Complete gasification of coal for firing boilers. C. H. S. TUPHOLME. *Chem. Met. Eng.*, **33**, 160–62 (1926).—A review of recent installations in England, where producer gas is being applied direct to steam generators. A detailed description with cuts, is given of the new Wollaston gas producer, which will consistently furnish 165 B.t.u. gas. M. E. M.

Industrial furnaces. ANON. *Mech. Eng.*, **48** [4], 356 (1926).—Discussions of papers presented by W. Trinks and Victor J. Azbe at the annual meeting of the A.S.M.E. are given. Leakage of fur. gases was considered a principal source of uneconomical opern. The importance of insulation was discussed. Insulation of fur. running at 3000° was considered impractical because the brickwork would melt. C. J. H.

Reduction of sulphur in producer gas. J. BRONN. *Fuels and Fur.*, **4** [4], 430 (1926).—This is an abstract of Report 89 of the German Iron and Steel Institute. The report shows that all of the sulphur content is harmful but only that which is not in the form of oxides, because the sulphur vapors, hydrogen sulphide, and carbon bisulphide are absorbed by the steel. It was found that the harmful combinations of sulphur are still present in producer gas after it passes the regenerators. A successful method for reducing these sulphur combinations is the addition of 2 to 3% of freshly burnt slaked lime to the coal which is being gasified. This causes a large part of the volatile sulphur to combine with the gas producer slag. The addition of lime is not only useful in steel plants but also in glass works because the sulphur causes formation of foam and discoloration in certain glasses. R. M. K.

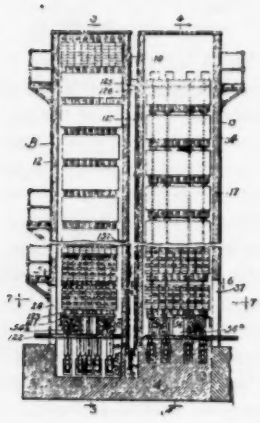
Operation of gas producers. F. S. BLOOM. *Fuels and Fur.*, **4** [4], 451–52 (1926).—The underlying factor of the quality of operation of the gas producer is the amt. of steam in the air blast. In some cases of producer operation the moisture content of the gas is excessive. Such cases are due to poor blower design. It is desirable to have a proper relation between the diameter of the steam nozzle, the venturi neck and the exit opening to secure greatest efficiency in the air and steam blast and hence in producer operation. Any factor which changes the resist. on the blower greatly affects the operating efficiency. It has been found that by the use of a fan blower the quantity of moisture can be regulated by the exhaust valve at the turbine. The use of a turbo-blower is an advantage in operating the gas producer for it allows the one very important factor, the quantity of moisture, to be controlled, which has the efficiency of the producer operation at a balance. It requires but little care to operate, but must be protected against freezing in cold weather and requires only such precautions as would be given any steam equipment. However, the jet blower has its advantages; it is rugged, will wear long, its first cost is low, and if designed properly will supply the max. amount of air per pound of steam that is desirable in good producer practice. R. M. K.

Recuperator principle applied to reversing reheating furnace. W. H. FITCH. *Fuels and Fur.*, **4** [4], 457–58 (1926).—Fuel savings can be effected at small cost by improve-

ments on rehtg. fur. by the application of a recuperator to do the work of a series of regenerators such as are found in the types of reversing flame furnaces now universally used. Drawings are given to illustrate the application of the recuperator principle to a reversing flame furnace. The principle points of interest are the uniform straight line temp. at which the air for combustion reaches the gas port of the fur. and the simplicity of design of the fur. as a whole. Details of the gas flow are given. A recuperator designed to do the same work as a regenerator requires less space. Tubes of silicon carbide have been found best for the recuperating surface, at points where the temp. of the gas is fairly high; cast iron tubes may be used at the lower temps. The silicon-carbide tubes are glazed to protect them from oxidation. This permits long life with max. rate of heat transfer. "Core busters," solid cylinders of fire clay on legs, were used to compel the air to pass in contact with the wall of the tube. The method of installing these tubes and "core busters" is described in detail. R. M. K.

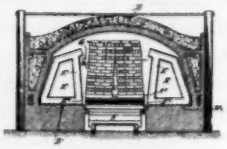
Factors concerning the operation of an oil-fired kiln. L. A. MEKLER. *Fuels and Fur.*, **4** [4], 466 (1926).—The kiln irrespective of its type, is a htg. device with a predetd. cycle and constantly increasing temps. which at the end of firing exceed 2000°F. The kiln obtains its heat from a large number of small fire boxes, each supplying a small portion of the total heat. Oil is a very intense fuel and has practically no intermediate combustion from carbon to carbon dioxide. All its heat value is developed in the fire boxes and distributed through the oil itself. To insure proper distribution of heat in kilns redesigned to burn oil, provision should be made for increased velocities of the gases of combustion through the kiln or for their immediate discharge from fire boxes as they are formed. Oil is a flexible fuel and any predetd. cycle can be closely followed. This is an advantage where the mats. being fired have critical transformation points. Oil firing is clean chemically as well as physically. The ease with which any rate of firing can be maintained with oil, results in a min. firing period. Oil is stored underground. The quality of the fuel may be kept uniform. R. M. K.

PATENTS

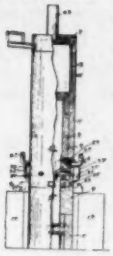


Continuously-operated kiln. CLAUDE SMITH. U. S. 1,578,559, March 30, 1926. In a kiln for firing and drying brick, etc., a vertical drying shaft and a vertical firing shaft, means for conveying mat. up the drying shaft, a firebox communicating with the firing shaft and a flue connecting the shafts near their respective tops.

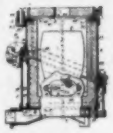
Loading kiln car. LUTHER T. STROMMER. U. S. 1,579,258, April 6, 1926. In firing bricks or analogous ware in tunnel kilns, the method of loading brick or analogous ware to be fired on a kiln car comprising a ware supporting platform which consists in arranging the lower portion of the ware on each car in columns resting on the car platform and separated by a longitudinally extending space at the center of the car, and in placing the remainder of the load on the tops of said columns to form a cap tying the upper ends of said columns together.



Kiln. HENRY F. GRUETZEMACHER, JR. U. S. 1,580,483, April 13,1926. In app. of the class described, in combination, a kiln combining a combustion chamber adjacent the lower part of the kiln, means for supplying fuel to said chamber, means for supplying air to said chamber, and means for htg. said air prior to delivering it to said chamber, said third means comprising a htg. chamber within the walls of the kiln above the combustion chamber, a conduit outside the kiln for conducting the htd. air from the htg. chamber down to the combustion chamber, means for controlling the velocity of the air in said circuit, and another means in said circuit for controlling the temp. of said air independently of the velocity. controlling means.



Crucible furnace. FRANKLIN M. ILER. U. S. 1,580,733, April 13, 1926. A crucible fur. comprising a casing adapted to enclose a crucible, said casing being divided into upper and lower sections, the meeting edges of which are inclined with respect to the horizontal and a horizontal pivot connecting said sections adjacent the uppermost portion of the wall of the lower section.



Tunnel kiln with preliminary heating, firing, and cooling zones. N. LENGERSDORFF. Brit. 236,229, Feb. 26, 1923. (*C. A.*)

Geology

Clay industry of Tennessee. JOSEPH K. ROBERKS AND R. LEE COLLINS. *Brick and Clay Rec.*, **68** [6], 460–63 (1926).—The clays of Tennessee, the chief producers, and ceramic plants are described. R. E. G.

Chemistry and Physics

Seger cones as a time-temperature integrating device. W. K. LEWIS AND E. D. RIES. *Chem. Met. Eng.*, **33,** 153–56(1926).—There is a certain temp. t_0 below which no cone will collapse. The authors show from actual observations that any cone which functions properly as a time-temp. integrating device, will if htd. at a constant rate of increase of temp. give a straight line if rate of htg. is plotted against time of collapse, measured from the time at which the temp. is t_0. It should be possible to calc. the slope of this line by a mathematical formula. When these lines were plotted for commercial cones, numbers 021 to 012a all had different slopes, and there was no consistent change in slope from one cone to the next. The minimum temp. of collapse, t_0, increased erratically from one cone to the next. The authors conclude that the behavior of these cones is highly inconsistent among themselves, when subjected to various conditions of htg. Standards of performance under heat should be adopted by the industries, and cones tested for conformity to the stand. M. E. M.

Colloid chemistry in filtration. A. V. DELAPORTE AND F. R. MANUEL. *The Canadian Engineer*, **50** [10], 94A–94B (1926).—Definitions of colloids, suspensoids, and emulsoids, with discussion of elec. charge phenomena. In the reaction of alum (aluminum sulphate) in the filtration of water, the $Al_2(SO_4)_3$ first breaks up into Al^{+++} and SO_4^{--} ions, and then the Al^{+++} unite with OH^- ions to produce the floc, $Al(OH)_3$. E. E. P.

Aqueous solutions of sodium silicates.—II. (Transport Numbers.) R. W. HARMAN. *Jour. Phys. Chem.*, **30** [3], 359–68 (1926).—The kind and mobilities of ions in sodium silicates of ratios 1 : 1, 1 : 2, 1 : 3, 1 : 4, and concn. ranging from 0.1 to 2.0 N_W were studied by the Hittorf method. The method of testing and the app. used are described, and the considerations involved in the analyses and calculations of results are discussed. Ratio 1 : 1 ionizes to Na^+, OH^-, and SiO_3^{--}, the $nSiO_3$ being small. In

other ratios, the silicate anion is not the simple SiO_3^{--} ion, but either an aggregation of simple silicate ions with or without colloidal silica, or a definite complex silicate ion. In ratio 1 : 1, the mobility of the SiO_3^{--} ion is about 70, and in other ratios approx. equal to that of the sodium ion, as found in condy. expts. E. E. P.

Absorption of heat in regenerators. ANON. *Archiv für Warmewirtschaft*, **7** [2], 58–59 (1926).—Distinction in principles of recuperation and regeneration, and heat economy considerations and calculations of regenerative fur. E. E. P.

Glass—Glazes—Enamels. EBERHARD ZSCHIMMER. *Ceram. Ind.*, **6** [4], 368–74 (1926).—The difficulty of mtg. varies directly with the LiO_2 content from hard glasses to enamels to glazes. Clay behaves the same to a certain degree. Tables are given showing the relationship of bottle glasses to glazes. R. E. G.

Analysis of lime. JOHN C. BAILAR. *Ind. Eng. Chem.*, **18** [4], 389 (1926).—Two methods for the detn. of calcium oxide in the presence of calcium carbonate have been developed, titration with a soln. of iodine and titration with a soln. of zinc chloride. "Available lime" means nothing until it is known for what purpose it is available. Different methods give different results. F. G. J.

The flow of water through soil. ANON. *The Engineer* (London), **141** (3664), 315–16 (1926).—Percolation of water through soil was studied in N. India by finding the water level at different distances from the Hansi branch of the West Jumna Canal. The results showed that the water percolated through the soil in a gradient curved somewhat like a hyperbola having its greatest slope adjacent to the canal. E. E. P.

Relationship between soluble iron and colloids in certain residual clays. G. R. MACCARTHY. *Soil Sci.*, **20**, 473–75 (1925); *Jour. Soc. Chem. Ind.*, **45B**, 207 (1926).—The ratio of the amt. of Fe sol. in dilute HCl per g. of mat. to the amt. per g. of the colloid fraction of the mat. gives a figure for the per cent colloids which agrees with that obtd. by the water-absorption ratio. With clays contg. much unweathered mat., and therefore much iron not colloidal, the results of the two methods are not concordant. The degree of weathering may thus be estimated, or, if completely weathered, the per cent colloid. H. H. S.

The action of silica on electolytes.—II. A. F. JOSEPH AND H. B. OAKLEY. *Jour. Chem. Soc.*, **127**, 2813–18 (1925); cf. *C. A.* **18**, 6.—The action of an alk. hydroxide on pure silica results in the formation of a solid silicate, part of which passes into soln. In accordance with the soly. of the silicates concerned, the amt. of solid silicate is very small with Na and K hydroxides, about 30% with Ba and nearly 100% with Ca. In the case of Na and K, the amt. of solid silicate produced is roughly proportional to the amt. of silica used, although the amt. of silicate in soln. is only slightly affected. This proves that the solid phases (silica and silicate) are directly concerned in the equil. The addn. of a neutral salt increases considerably the amt. of solid silicate formed. (*C. A.*)

Beidellite, a new mineral name. E. S. LARSEN AND E. T. WHERRY. *Jour. Wash. Acad. Sci.*, **15**, 465–66 (1925).—Restricting the name leverrierite as a species name to vermicular mat. with the Al_2O_3 : SiO_2 ratio 1 : 2, a compact-cryst., compd. with a 1 : 3 ratio from Beidell, Colo. previously described under that name (*C. A.* **11**, 1806) is now named *beidellite*. It is probably orthorhombic, and belongs to a mineral group lying, with respect to the Al-Si ratio, between the kaolinite and the pyrophyllite groups. (*C. A.*)

The role of colloidal solutions in the formation of mineral and metalliferous deposits. RENÉ VAN AUBEL. *Rev. gen. sci.*, **36**, 671–80 (1925).—This review considers: (1) nature and localization of the colloidal minerals, (2) structure of the colloidal minerals of the deposits, and (3) the colloidal solns. and certain classic mineralized deposits. This last topic is developed under 16 sub-topics. Apparently the theory of colloidal solns. gives a working hypothesis for further study of the deep deposits. (*C. A.*)

Chemical alteration of granite beneath peat. E. BLANCK AND A. RIESER. *Chemie der Erde*, **2**, 15–48 (1925).—A detailed review and discussion is given of the lit. on the formation of clay or kaolin by weathering processes, more particularly in association with peat and lignite deposits. Anal. are compared of fresh granite, from the Harz Mts., and of the weathered rock taken from below a layer of peat and from the surface. There is no evidence of the formation of kaolin under these conditions. SO_3 was found in the weathered products, in peat, sphagnum-moss and moor-waters, and it is concluded that this has some action in the weathering processes. (*C. A.*)

The system $CaSiO_3$–$MgSiO_3$–$FeSiO_3$, especially in diallage, augite and hornblende of the gabbro-basaltic magmas. PETER CHIRVINSKII. *Centr. Mineral. Geol., A* **1925**, 199–202.—Av. anal. of diallage, augite and basaltic hornblende suggest $2CaSiO_3$.-3(Mg, Fe)SiO_3 as a basic formula for these minerals. $MgSiO_3$: $FeSiO_3$ averages 3 : 1. This empirical av. formula can be variously interpreted, *e. g.*, as representing diopside, $CaMgSi_2O_6$ (77.14 mol. %), with isomorphous mixt. of (Fe, Mg, Mn)SiO_3 (22.8 mol. %) or as an unstable double salt involving the actinolite and wollastonite mols., $Ca(Fe, Mg)_3Si_4O_{12}$. (*C. A.*)

Chemical constitution of the gehlenite-melilite group. B. GOSSNER. *Chemie der Erde*, **2**, 103–13 (1925).—The isomorphous mixing of such complex mols. as suggested by Buddington (*C. A.* **16**, 1058) is regarded as improbable; and G. traces a connection between the minerals of the gehlenite-melilite group and the monoclinic ("pseudo-tetragonal") pyroxenes. They are regarded as double compds. CaO + pyroxene, of the form $CaO.[SiO_3Ca.SiO_3Mg]$, where SiO_3Mg is replaceable by Al_2O_3, and Si_2O_6MgCa by Si_2O_6AlNa. Gehlenite is written $CaO.[SiO_3Ca.Al_2O_3]$ and melilite as $2CaO.[Si_2O_6MgCa.Si_2O_6AlNa]$. Åkermanite approaches $CaO.[SiO_3Ca.SiO_3Mg]$. (*C. A.*)

Simple stoichiometric relations of the average biotite of granite and the connection between the anorthite and the biotite content of granite. PETER CHIRVINSKII. *Centr. Mineral. Geol., A* **1925**, 304–13.—Av. anal. of biotite in granites suggest that the equil. center for this mineral is an equimolar mixt. of the muscovite and olivine mols. Granites and closely related rock types contain anorthite and biotite in about equal propns. The anorthite-biotite system in idealized form may accordingly be represented thus: $[CaAl_2Si_2O_8 + CaAl_2Si_2O_8] + [(K, Na, H)_2Al_2Si_2O_8 + (Fe, Mg)_2SiO_4]$. (*C. A.*)

Hydrolysis of mica. P. A. ZEMYATCHENSKII. *Ann. Inst. Anal. Phys.-Chem. Leningrad*, **2**, 484–85 (1925).—When htd. with water, muscovite undergoes energetic hydrolysis and gradually approaches kaolinite in compn. The extent to which this change takes place depends on the duration of the action and on the fineness of the mica; the change may be accelerated and rendered complete by raising the temp. Muscovite is decomposed more readily than kaolinite when treated with 10% HCl soln. Slight hydrolytic decompn. of muscovite doubtless plays a large part in the process of the decay of mica. (*C. A.*)

Heating curves of Tichvinski bauxites. N. S. KURNAKOV AND G. G. URAZOV. *Ann. Inst. Phys.-Chem. Anal. Leningrad.*, **2**, 495–96 (1924).—The htg. curve of Ural diasporite exhibits an arrest at 509–555°, but no exothermic effect at a higher temp. Artificial hydrargillite shows 2 arrests, at 200–295° and 509°, resp. After expulsion of the bulk of its water at 100°, colloidal hydrated alumina shows both the diasporite and the hydrargillite arrests. Tichvinski bauxites with high silica contents also show the diasporite and hydrargillite arrests, and, in addn., an arrest at about 567°, corresponding with kaolinite. An exothermic effect at a higher temp. is observed sometimes, but not always. (*C. A.*)

Thermal analysis of clays and bauxites. N. S. KURNAKOV AND G. G. URAZOV. *Ann. Inst. Phys.-Chem. Anal. Leningrad*, **2**, 496–98 (1924).—When a pure kaolin Al_2O_3.-$2SiO_2.nH_2O$ (n = about 2), is htd. an endothermic arrest occurs at 558–605° because

of the elimination of H_2O and an exothermic effect (recalescence) at 950–1000°. Under identical conditions the cryst. monohydrated alumina, diasporite, shows a temp. arrest at 509–555°, but, like other hydrated forms of alumina investigated, no exothermic effect. The natural trihydrate (gibbsite) or artificial trihydrate is characterized by 2 endothermic arrests on its htg. curve, at 202–296° and about 500°, the latter coinciding with that observed with diasporite. With the richly aluminiferous Tichvinski bauxites contg. up to 15% of water and not more than 12–15% of SiO_2, only endothermic arrest is found corresponding with that of diasporite (509–555°); if the silica exceeds 12–15% the kaolinite arrest (558–605°) also is encountered. The latter bauxites evidently consist of a mixt. of diasporite and kaolinite; further, bauxites contg. more than 14–15% of H_2O exhibit also a lower arrest at 200–296°, indicating the presence of hydrargillite. (*C. A.*)

Some double fluorides of zirconium. M. M. WINDSOR. *Jour. Am. Chem. Soc.*, **48,** 310–12 (1926).—The following 6 new double fluorides of Zr were prepd. by dissolving ZrO_2 in HF, adding an equiv. amt. of the base in EtOH and either crystg. or pptg. with Me_2CO: *aniline* (*A*) *deriv.*, $A_2H_2ZrF_6.H_2O$; *brucine* (*B*) *deriv.*, $B_2H_2ZrF_6.7H_2O$; *cinchonine* (*C*) *deriv.*, $CH_2ZrF_6.2H_2O$; *quinine* (*D*) *deriv.*, $D(ZrF_4)_2$; *quinidine* (*E*) *deriv.*, $E(HZrF_5)$. $ZrF_4.4H_2O$; *strychnine* (*F*) *deriv.*, $F_3(HZrF_5)_2.2H_2O$. All were white and transparent when dry and were sol. in EtOH and in hot and cold H_2O. A double fluoride with cinchonidine could not be crystd. from the impure jelly first obtd. In the prepn. of the aniline deriv., a *red cryst. compd.* was obtd., which was probably a *double fluoride of some oxidation product of aniline*, contg. 29.87% F and 32.68% Zr. Solns. of the quinidine deriv. were bluish and opalescent. These compds. should be of value in the development of a method for the sepn. of Zr and Ti similar to that of Schaeffer (*C. A.*, **3,** 519) for the sepn. of Ti from Co and Ta. (*C. A.*)

An investigation of the green color of tungstic oxide. NICOL H. SMITH AND HIRAM S. LUKENS. *Chem. News*, **132,** 33–35 (1925).—Samples of WO_3, varying in color from light to dark green, did not change in wt. or in color when heated in a current of O. All green samples contd. Na salts, whereas yellow oxides contd. only traces. Furthermore addn. of Mn or Fe compds. in the prepn. of the yellow oxide did not give a green product on ignition. Ignited green WO_3 on being dissolved in NH_4OH and repptd. with acid gave a yellow oxide free of Na salts. On the other hand the depth of green could be controlled in the prepn. of the WO_3 by the concn. of the Na_2WO_4 treated with acid and therefore by the amt. of Na compds. in the final product. It was thus proved that the green color of WO_3 is due to Na compds. and that the depth of color varies with the amt. Light does not turn yellow WO_3 to green WO_3, and in fact it has, contrary to the view of v. Liempt (*C. A.* **16,** 880), no part in the phenomena described. During the evapn. of a soln. of $(NH_4)_2WO_4$, NH_4Cl, NH_4OH and NaCl, a white cryst. *Na-NH₄ complex* of the compn. $10WO_3.4Na_2O+4(10WO_3.4(NH_4)_2O)+50H_2O$ was obtd. (cf. Gibbs, *Am. Chem. Jour.*, **1,** 229 (1879)). On ignition it first became yellow and then intense green, the latter color arising from the presence of Na compds. which could not be extd. (*C. A.*)

Equilibrium diagram of ferrous oxide and silica. O. VON KEIL AND A. DAMMANN. *Stahl u. Eisen*, **45,** 890 (1925).—The equil. diagram for FeO-SiO_2 mixts. shows 2 eutectic points (1115° and 1075° at about 40% and 4% SiO_2, resp.), and a max. at 1503° with 30% SiO_2 in the mixt. corresponding to the compd. $2FeO.SiO_2$. With more than 45% SiO_2 present, the m. p. is too high to be detd. accurately. (*C. A.*)

PATENT

Process of separating hafnium and zirconium. DIRK COSTER AND GEORG VON HEVESY. U. S. 1,580,650, April 13, 1926. The method of sepg. hafnium and zirconium,

which comprises progressively fractionally sepg. one of the elements as hydroxide, and collecting the separated fractions.

General

Mining and transporting kaolin in old Virginia. ANON. *Clay Worker*, **85** [3], 210–11 (1926).—The Cold Spring Mining Co., Augusta Co., Va., mines kaolin which is transported by overhead tramway nearly 3 miles to the railroad. As there is an 800 ft. drop, the loaded cars operate the line by gravity. This is a cheap efficient way to transport clay over rough country. R. E. G.

A four-point mixing diagram. K. M. SMITH AND W. L. SAMPLE. *Bull. Amer. Ceram. Soc.*, **5** [4], 213–15 (1926).—The triaxial mixing diagram is discussed briefly. The use of the 4-point diagram consisting of a square subdivided into smaller squares, the number of which is optional, is explained. The general rule for obtaining the number of parts of any of the 4 corner members in any given mixt. is to count the number of squares included in the angle opposite the one contg. the corner member. E. J. V.

The Antioch plan of coöperative education as it affects students in chemistry. C. S. ADAMS. *Jour. Chem. Education*, **2**, 900–6 (1925). (*C. A.*)

The organization and work of the United States Bureau of Standards. G. K. BURGESS. *Jour. Chem. Education*, **3**, 7–28 (1926). (*C. A.*)

Fifty-seventh annual review and year book number. ANON. *Eng. Mining Jour.-Press.*, **121**, No. 3 (1926); cf. *C. A.* **19**, 809.—This number contains mining and trade information for the year 1925 on Cu, Pb, Zn, Au, Ag, Fe, petroleum, Mn, Ni, chromite, W, Co, Mo, Pt, Hg, As, Sb, Bi, bauxite, Al, Ra, U, V, Cd, Ce, Se, Te, Tl, Ti, Th, Zr, asbestos, mica, graphite, talc, tripoli, diatomite, SiO_2, feldspar, kaolin, gypsum, magnesite, barytes, fluorspar, borax, phosphate rock, nitrate, potash, S, and pyrites; regional summaries of the mining indus. are given; and papers on *Milling and Flotation* by C. E. LOCKE, *Hydrometallurgy* by A. W. ALLEN, *Pyrometallurgy* by E. H. ROBIE and *Iron and Steel Metallurgy* by BRADLEY STOUGHTON. (*C. A.*)

BOOK

SEARLE, A. B.: **The Chemistry and Physics of Clays and Other Ceramic Materials.** New York: Van Nostrand Co. 695 pp. Reviewed in *Expt. Sta. Record*, **52**, 811.

PATENTS

Coated fibrous article and coating composition therefor. CHARLES H. CROWELL. U. S. 1,577,450, March 23, 1926. The coated fibrous article having a water-repellent silicate coating with which finely divided bentonite clay has been mixed to minimize chipping or cracking.

Process for the production of artificial stone, stoneware, and the like from boiler slag, dust slag, or ashes. FRIEDRICH KÖRBER AND WILHELM HESSEL. U. S. 1,580,906, April 13, 1926. A process for producing stoneware from subs. of the character of coal clinker such as slags comprising the reduction of the clinker or slag to a finely divided condition, molding the finely divided clinker or slag into the form of the object to be produced and then sintering the molded body, substantially as decribed.

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A Timely Suggestion

We hope the English coal strike may be settled before this advertisement appears—but—it should suggest to you American Potters the need of protecting your business by the use of American clays.

One or more potteries in every branch of the ceramic field is making a 100% American body—except one—vitreous dinner ware. This is a precedent beyond dispute. It can be done successfully.

The industry was founded on English clay mixtures, but leading ceramists have stated that its slowness in adopting its own clays is due to that fact rather than to any inferiority of the clays.

American clays are different but not inferior. We are prepared to supply formulas for using them.

CONSIDER—

1. American clays from reliable producers are as uniform in quality as foreign clays.
2. American clay can be produced in quantity to fill all needs if the miners receive sufficient encouragement from the potters.
3. American clays are on the whole less expensive than imported pottery clays.
4. American clay is shipped all rail in single car lots as you need it.

We suggest that the time is opportune for the White Ware Industry to take concerted action toward increasing the use of American clays.

Edgar Brothers Co. **R. T. Vanderbilt Co.**
Harris Clay Co.

Producers of Reliable American Clays

They Are Using It

With more than a 50 per cent saving in the cost of their Opacifier—what a tremendous sales advantage in better profits or less worry about competition.

These are facts

Today six plants are using Opax for every plant that used it a year ago.

Today the industry uses Ten Tons of Opax for every Ton it used a year ago.

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BULLETIN

of the

AMERICAN CERAMIC SOCIETY

A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific and Art Questions and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

Mary G. Sheerer, Arthur Baggs, M. E. Manson, H. G. Wolfram	Art, Enamel	F. C. Flint, A. N. Finn, R. F. Geller, L. J. Trostel, F. H. Rhead, R. F. Sherwood	Glass, Refractories, White Wares	D. F. Albery, G. M. Tucker, R. A. Horning, H. R. Straight	Terra Cotta, Heavy Clay Products

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Vol. 5 June, 1926 No. 6

EDITORIAL

FEDERAL PATERNALISM

Many editorials and lectures of late have cautioned against extension of federal bureaucracy. Either absolute or paternal control by federal agencies leads to destruction of democracy, self-expression, personal liberties and independence. This republic was founded on the principle of maximum of personal liberty limited only by protection of the individual through federated government.

There is no denying that the southern states had a considerable fundamental justice in the cause for which they fought. They fought for the right of self expression but made the mistake of carrying their rightful reasoning to the point of secession.

There is strength in federation. The present day movement toward federation of nations is sound fundamentally, and the league of nations is a certainty when all nations shall have attained sufficient intellectual and moral character. Treaties are predicated on the need for international federation.

Federation to the extent of mutual assistance to a given end is of mutual advantage but a federation that results in centralization of control creates dictatorship, the exact opposite of the fundamental principle on which this republican form of government was founded.

What is true in civil and trade control is true also in the educational, religious and moral affairs. Federal control through bureaus of the educational, religious and moral relations is dangerous. These should be decentralized just as far as it is practical.

Exploitation of the nation's natural resources and the finding of means of economical utilizations is a legitimate federal activity. Standardization and specifications of materials and products; leadership in product simplification, and elimination of waste and other activities looking to betterment of and economies in manufacturing are beneficial federal activities.

What is true of the limitation in federal control and in federal encroachment on personal rights and duties is true also of federal aid. England's system of doles to the coal miners has so confused governmental, industrial and personal rights and duties as to cause a universal strike and a national embarrassment. Just to the extent as the United States of America allows its federal facilities to be used for investigations other than those which are for fundamental rather than applied information, it will be robbing its citizens of their individual rights and obligations. Coöperative investigations on manufacturing methods or equipment or on product is a decided step toward a system of doles to the industries. Federal investigations should be limited to those which disclose information needed in standards and specifications or in the finding of industrial use or more economical use of the national mineral supply.

For the federal and state governments to make available their research facilities for use at cost by industrial firms or groups is excellent. This should be a rental of space and equipment and employment of personal service without involving federal prestige and responsibilities. For the government to furnish facilities for private or semi-private investigations for any sum less than cost makes the government a party to and responsible for the results obtained, and subjects the financing coöperating industrialists to restrictions that lead to embarrassments. The government can not bid for coöperative investigations without sacrificing the fundamental principles of decentralization of rights and obligations on which this federated government was founded. Federal paternalism is undemocratic and in conflict with the principles of self government.

PAPERS AND DISCUSSIONS

ADDRESS OF RETIRING PRESIDENT

By E. Ward Tillotson

This Twenty-eighth Annual Meeting of the American Ceramic Society marks the conclusion of the twenty-seventh year of the organization. During this quarter-century, the Society has grown in size and influence until now it ranks as a major technical association, and is indeed the largest and most active organization devoted to ceramics in the world. It has always had individuality, which is well illustrated by the character of its conventions. In no other large society does so great a percentage of the membership attend the annual meetings consistently, and no other society excels ours in spirit of comradeship.

Expected obligations rather than formal regulations constitute the fundamental strength of the Society and give it the character and influence which it possesses. It has always been a real pleasure to me to be a member of the organization and to take part in its activities, and for the honor of serving as President, the highest distinction that the Society can bestow, I am sincerely grateful. The experience has been interesting and pleasurable, and I wish to extend my thanks to the Board of Trustees and to the several officers and appointees for their services during the year.

At this time it is appropriate that I present a brief review of certain of the Society's activities. Two important subjects are: finances and membership.

Activities

Financial Last year my predecessor was able to report a substantial profit in the annual operations. This year the balance is in the red by about two thirds of last year's gain. This condition has resulted in spite of an increase in income and is due primarily to greater costs in the printing of the *Journal* and to increased postal rates. The cost of the *Journal* alone during 1925 was $3,000 more than for 1924, and other expenses have necessarily been greater; the growth in income was not sufficient to cover these increased expenses, and hence a deficit of $2057.67 is recorded for the past year.

The membership record for the year is also disappointing. The number of new members secured during the year has not been sufficient to provide for a healthy growth in membership.

In brief, the finances and the membership of the Society have shown slight declines instead of the advances which are hoped for and expected. The Society, nevertheless, is a going concern. The innova-

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926.

tion made some years ago in the appointment of a full-time secretary-editor has been amply justified. Yet this SOCIETY cannot be content only to maintain a given status, much less recede from it. It is not possible to develop the literary and social functions of the organization as outlined in the Constitution without at the same time providing an adequate income for these purposes. Two choices are at once apparent, namely: either a decrease in expenses or an increase in income. Both means are available for practical application. This year the *Journal* is being printed by the Banta Publishing Company, of Menasha, Wisconsin, a firm experienced in printing scientific journals. It is expected that the cost of the periodical will be materially reduced during 1926.

Membership The principal income of the SOCIETY is from advertising and from membership dues. The income from dues can be increased only by securing new members, and it is plain that the number of prospective members far exceeds the number of actual members at present. The SOCIETY provides for a membership committee, the purpose of which is to "undertake systematically the enlargement of the membership of the SOCIETY." You who have followed the announcements in the *Bulletin* will realize that all members of the SOCIETY are in spirit members of that committee and many new members can thus be secured by individual effort.

The effectiveness of the present arrangement is open to question. Recently a retiring president in speaking of the membership committee said, "It did not function this year." It has been said that the membership committee is the sales department of the SOCIETY. If this is so, it may be asked whether this extension work should not be made a permanent part of the business organization and attached to the home office. We have a general secretary and editor and an advertising manager whose efficient work is familiar to you. An arrangement whereby the duties of this committee may be accomplished in a more business-like way is worthy of consideration.

Advertising The main source of income, that of advertising, is always a problem in the case of a publication such as our *Journal*. A scientific periodical is not considered to be as desirable an advertising medium as an industrial or trade journal. Yet our advertising nearly pays for the printing of our *Journal*, although not for the editorial and office expenses connected with its publication. The SOCIETY does not desire to compete for advertising with the commercial ceramic press. The selling of space in the *Journal* is the result of necessity and not of choice.

When the plans for issuing a *Bulletin* were under consideration, attention was given to the suggestion of making it a separate publication. The decision which resulted in the present plan was dictated by

a caution which seemed wise at the time. The arrangement however should not be continued if it has outgrown its usefulness, or if it is hindering the normal development of our publications. The issuance of the *Bulletin* as a separate industrial journal would offer certain editorial opportunities and probably advertising advantages, but it is likely that the advertising in the *Journal* and *Abstracts* would be nominal and that the *Bulletin* would have the responsibility of providing practically all of the income from this source. This is a question for careful consideration by every one who reads the publications of the SOCIETY.

Membership Classification of Fellows

During the year, two suggestions of considerable importance have been brought to my attention. Both have to do with changes that were made several years ago in the SOCIETY's organization. Ever since the grade of active member was deprived of its original significance, it has been felt by many that the SOCIETY had lost rather than gained by the change, that the making automatic of active membership had withdrawn the incentive that it offered to the associate members. The suggestion was therefore made that a grade of membership be created not identical with the older active membership, by which service to the SOCIETY and to the American industries might be recognized. Such membership would have a distinctive designation, such, for example, as FELLOWS OF THE AMERICAN CERAMIC SOCIETY. Expressions of opinion by a number of present and former officers of the SOCIETY indicate that a real difference in view exists concerning the desirability of this suggestion.

Museums as Honorary Members

In this same connection motions have been presented that honorary membership be granted to certain museums having large ceramic interests and to ceramic educational institutions.

These questions are presented here because the membership at large will have to make the decision either by direct vote or by a change in the Constitution. The same condition applies to the following proposal, which is the second subject of general interest.

Method of Nominating

Several years ago there was instituted an elected nominating committee, the Secretary acting as chairman without vote. While the Constitution is silent upon the question, these committees have followed the usual custom of presenting one name for each office. The Constitution provides that ten members may act as a self-appointed nominating committee, but this privilege has not been exercised during the last few years. It is held, therefore, that nomination is equivalent to election and that this is not a healthy condition in the SOCIETY's affairs.

The foregoing suggestions have been presented without recommendations for your thoughtful consideration.

Objects Served by the Society

The object of this SOCIETY as expressed in its Constitution is to advance the arts and sciences relating to the silicate industries.

As means for accomplishing this, provisions are made for meetings, for the exchange of information, for the reading of papers, for the placing of these on permanent record in the ceramic literature, for officers and committees, and for certain classifications of its membership.

It is of interest at this time to examine the trend of the activities of the SOCIETY and of their significance.

The membership of the SOCIETY is classified in two ways: professionally in *professional* divisions and geographically in *geographical* sections. These two groups form the framework of the organization. Like the warp and the filling threads in a woven textile, each has its place in the complete fabric. The decisions being composed of those members with common interest are by nature fundamentally strong.

The Divisions Generally speaking, all of the Divisions consistently present strong programs and in their contribution to the SOCIETY's activities justify their existence. Some divisional committees are active and some are idle. The question is asked, "Why is a committee?" The divisional committees which parallel the general committees of the SOCIETY provide means for each Division to participate in all activities which may be of benefit to the particular industries represented by that division. Idle committees therefore represent the failure to take the greatest advantage of the opportunities for the advancement of the industries. Divisions are to be encouraged, however, in developing their activities in a way best suited to their requirements, when such activities are consistent with the general plans of the SOCIETY. The initiative of one Division in providing a fund to carry on the investigation of a technical problem is a wholly admirable example of such an effort.

Most of the Divisions are in a measure self-contained with only general ties of common interest. One of the Divisions, however, the Art Division, is conducting an important work which would be increased in effectiveness if a means could be worked out for a better coördination of the work of other divisions with that of the Art Division. In this place attention is drawn particularly to an editorial in the *Bulletin* for January, entitled "American Ceramics for America," and to the American Ceramic Art Symposium in the same issue.

Local Sections The local Sections of the SOCIETY have in general been less virile than the Divisions, particularly since

the formation of the Divisions. This fact and some of the difficulties involved are known to those who have taken an active part in sectional affairs.

Every local Section is made up of representatives of several professional groups. Long programs which contain something of interest to the several groups are time-consuming and require daylight meetings, while an evening meeting must be of a more limited interest and is often in competition with other attractions. Each Section is faced with local problems and it appears that each must adapt itself to its peculiar conditions. In some cases only a few meetings during the course of the year may be most satisfactory; in others, more frequent meetings with less elaborate programs may be successful.

One Section has been meeting monthly during the past year and there is every prospect that this plan will be continued during the coming year. The local Section is too potentially valuable to the SOCIETY to permit of its being abandoned. Besides permitting of the strengthening of friendships and of promoting the social relationships of its members, it is the only representative group of the SOCIETY which may participate in affairs of interest to the community. Such activities are primarily educational, since the publicity which may be secured as a result of sectional meetings, public lectures sponsored by the section, and joint meetings with sections of other technical societies' help to spread the gospel of ceramics beyond the confines of the SOCIETY and the industries, and if continued consistently will give ceramics its true place in the public consciousness.

It seems to me that the local Sections find in these social and public educational activities their largest service to the SOCIETY and to the profession.

Education Education was a prominent theme at last year's convention and at the summer and fall meetings during 1925. These discussions have brought forth a real interest on the part of industrialists as well as of educators and have pointed out the trend of ceramic education. One characteristic that cannot be overlooked is that modern technical education is moving in the direction of greater specialization. The professional man may possess a broad training in the fundamentals of his science, but eventually, from choice or necessity, he finds his greatest success in becoming expert in a rather narrow field within the profession. The picture of a mechanic applying for a position and claiming five years of experience in tightening nut No. 87 on a well-known mechanical device is an extreme illustration of the general situation. We may or we may not consider that this represents education in the true sense, but it certainly represents what collegiate instruction is expected to accomplish.

In this respect education is perhaps of necessity following in the path of the developments of technology. Mechanical developments in industry are representative of this order. A mechanism is devised to carry out some operation or series of operations, and in proportion to its complexity, ingenuity and usefulness, it becomes limited in the variety of things that it can accomplish. For example, a certain automatic glass-forming mechanism, a highly complicated and very successful machine, is capable of making only one type of article, and for the most economical operation only one size of article may be made on a given unit. This may illustrate well the tendency to mechanical specialization, but a similar trend follows from any technological development. Industry is constantly requiring products which are adapted to particular uses, and as old products are improved or as new products are developed for specific purposes so there is evolved at the same time a professional expertism that must be sustained by specialized instruction either in the school or in the factory.

Indeed, one may fairly ask whether, after all, the adaption of product to its intended use is not the soundest basis of technology. The ceramic industries are favored above most other industries in that raw materials are readily available and relatively cheap. The full development of these industries cannot rest wholly upon the lessening of manufacturing costs. It will depend largely upon the degree to which their products satisfy the needs of use and the extent of the discovery of new and specialized ceramic products. The trend of ceramic industrial development is certainly in that direction. If science lags behind technology, as is often said, it is also true that education lags behind the requirements of industry.

Education from Standpoint of Product

Is it not possible, therefore, that the next development in ceramic education might well be based upon a consideration of ceramic products? Surely an understanding of the characteristics of ceramic products in relation to their prospective uses would familiarize the student with the current commercial products of his profession and a full knowledge of their limitations and possibilities would be of inestimable advantage to the graduate ceramist, whether he is to engage in ceramic manufacture or whether he will be required to select ceramic materials for use in some other industry. Certainly that approach to the study of ceramics, far from interfering with the teaching of the fundamentals of science and technology should be a material aid in giving him a well-balanced understanding of the industry and of his profession.

Coöperation Essential

This trend toward specialization on the part of industry and of the professional man makes for a divergence of immediate interests and

for eventual isolation unless the unifying influence of coöperation is introduced. At times it seems as if the word coöperation is overworked and even misused. It does not refer to a way of arranging that some one else only will do what you wish to have accomplished. This SOCIETY is a fine living example of coöperation between groups of men and of industries, some of which have very slender threads of common interest.

Coöperation is a pooling of resources and efforts for mutual benefits, and it reaches its heights not only in bringing together material resources and physical efforts but also in the exchange of intelligence and of intellectual resources.

Federation of Research Agencies

Inasmuch as research is a means for the advancement of the ceramic industries, this SOCIETY is interested in the promotion of scientific and industrial research. In the carrying on of research successfully coöperation between the several interested parties is essential. This is obvious, but there is possibly a larger coöperation or perhaps a coördination of investigational effort in which the SOCIETY may serve as a unifying influence. The number of institutions in which research in ceramics is being or may be conducted is increasing. It seems, however, as if the facilities for research are never adequate for the needs of industry, and it is desirable therefore that such facilities be employed in the most effective and economical way. It appears that some such coördination would be desirable and when it develops it is logical that this SOCIETY's organization, comprehending as it does all phases of ceramic activities, should have an important part in this coördination.

In another direction the SOCIETY makes contact with a second group whose interest in research is no less keen, namely, the industrial executive and the trade associations. It cannot attain the fullness of accomplishment in promoting education and research if those directly concerned with using commercially the results of research are not made a part of the enterprise. These larger activities of the SOCIETY have been under consideration by its officers and members for several years, and plans for making them possible have been the subject of much discussion. It is not possible to enter into further detail at this time regarding these suggestions. A resumé of their status is given in the *Bulletin* for January under the title "Coördinating Ceramic Research." These projects have attracted the attention and the interest of industrialists and of associations. While their full realization will only follow a period of development, it is believed that such a realization is possible and that the way to a greater service to the industries is indicated in these plans.

The SOCIETY has a record in the past of which it is proud. It has experienced a marvelous development in the last decade and faces the possibilities of still greater accomplishments in the future. This,

however, can be brought about only through the united efforts of every member of the SOCIETY in supporting the Divisions and local Sections and the other activities through which the purposes of the SOCIETY must be accomplished.

MELLON INSTITUTE
PITTSBURGH, PA.

THE APPLICATION OF ELECTRIC HEAT TO GLASS ANNEALING[1]

BY A. N. OTIS[2]

ABSTRACT

A descriptive paper in which the author refers to electrically heated travelling leers and stationary furnaces now in use for annealing various kinds of glassware, including special ware, miniature lamp bulbs and stems, conveyor leers for bottles, and box furnaces for optical glass.

The operating characteristics of the conveyor leers are discussed, and the electric energy consumed for a typical week's run is given, from which as a basis, costs of operation may be estimated.

An equipment for annealing lenses and prisms of optical glass is described in some detail, and a proposed furnace with control equipment of great accuracy for annealing large disks for telescopes is illustrated and discussed at some length.

(1) The first electrically heated leer to be used on a commercial scale, was installed in the vacuum tube department at the Schenectady Works of the General Electric Company in 1920. This leer consists of a relatively short horizontal heated chamber, elevated at some distance above the floor, with a vertical connecting chamber at each end, through which the ware passes to enter and to leave the horizontal heated chamber.

The entrance side is provided with heaters for preheating the ware and conveyor, while the exit side forms a part of the cooling space.

The ware is carried in swinging trays 30 inches long by 8 inches wide, which may be hung from the cross bars of a continuous conveyor, the trays being modified in details to support a variety of ware.

The openings to the vertical entrance and exit chambers are restricted to just clear the trays in order to eliminate air currents through the chambers.

This leer has been in operation over five years, annealing various sizes of vacuum tubes, X-ray tubes, supporting stems, etc. Most of this ware is relatively thin and consists of a body to which stems, supports, or other inwardly or outwardly projecting parts have been attached by fusing. Examination with a polariscope shows that the strains at these joints, as well as other parts of the ware, are entirely removed, and that the ware is completely and uniformly annealed.

[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Atlanta, Ga., Feb., 1926. (Glass Division). Received January 11, 1926.

[2] Industrial Heating Engineering Department, General Electric Company, Schenectady, N. Y.

The leer is provided with adjustable speed drive and adjustable temperature control, so that a wide variety of annealing cycles can be produced, to take care of the various kinds of ware to be annealed.

Figure 1 shows a view of the leer and also some of the swinging trays on which the ware is carried. The ware is relatively large in size but light in weight, and the shapes are such that close packing is not practicable.

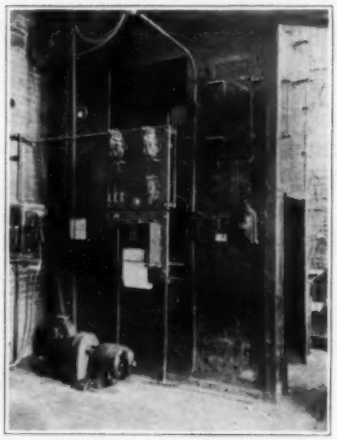

FIG. 1.

From 30 to 70 X-ray bulbs are annealed per hour, depending on the size.

The building in which this leer is located is now being dismantled, and the equipment is being removed to more commodious quarters. A new leer of the same type, but considerably larger, is being built, the heating chamber being approximately 27 feet long and 5 feet wide. Swinging pans or trays 4 feet long by 15 inches wide will be hung every two feet, and with a conveyor speed of 20 feet per hour, 10 trays per hour will pass through. The loaded conveyor passes downward out of the heating chamber at the rear end into a cooling chamber below it, and then forward through the cooling chamber to the front end where the ware is loaded and unloaded.

The connected load will be 120 kw. divided into four heat zones, each with adjustable automatic temperature control, and it is estimated that 50 to 60 kwh. per hour will be required in operation.

A view of this leer partly completed is shown in Fig. 2.

FIG. 2.

(2) An electrically heated leer for annealing miniature lamp bulbs in bulk was installed at the National Lamp Works, Cleveland, Ohio, early in 1921. It was put in operation in April of that year, and has been in constant use since.

The inside dimensions are 16 feet long, 30 inches wide,

and 24 inches high. The bulbs are carried through in pans by means of an intermittent hand operated conveyor. The leer is shown in Fig. 3. The connected load is 60 kw., divided into two automatically controlled heat zones, and the output is from 15,000 to 50,000 bulbs per hour depending on the size, with an average power consumption of 42 kwh. per hour.

The bulbs are carried through in sheet metal pans or trays, filled to about two inches thickness, and require two hours for the annealing cycle.

These bulbs are blown from glass tubing by automatic machines, and most of them are sealed in the cutting-off process, so that the interior is under a partial vacuum. The walls are very thin, while the necks are fairly heavy, and being piled on top of each other in trays, and containing a partial vacuum, they are extremely sensitive to annealing.

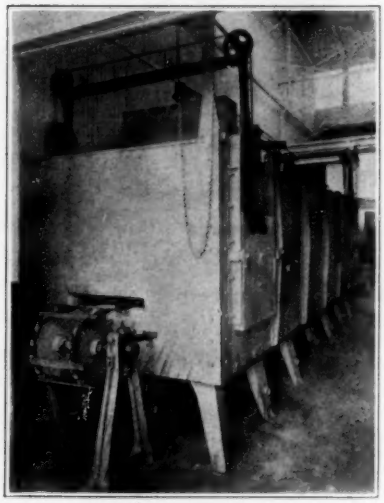

FIG. 3.

The temperature and time must be sufficient to anneal the heavy necks, and yet not sufficient to soften the bulbs so that they will flatten or deform from the weight of the upper layers in the tray, or collapse from the vacuum within them. If the temperature becomes too high, the bulbs will flatten and be ruined, and if not high enough the necks will be strained and will not cut off evenly in the subsequent operation.

The necks are cut off by bringing them into contact with an abrasive wheel, and if they are fully annealed the cut will be true and even and the bulbs are then ready for manufacturing into lamps; but if the cut is jagged, the bulbs must either be scrapped or ground to an even surface and carefully washed to remove the ground glass from the interior.

It is conservatively estimated that a direct saving of 20% in the manufacture of bulbs results from the perfect annealing secured with this leer, as rejections and grinding have been eliminated, and further that much greater savings are secured in the processes of assembling into lamps, since well-annealed bulbs show much less tendency to breakage than strained or unevenly tempered bulbs. Many millions of bulbs per year are annealed in this leer, of a quality and uniformity which is quite remarkable.

(3) A somewhat similar leer for annealing filament stems, has more recently been installed at the Illinois Miniature Lamp Division at Chicago (see Fig. 4) and has produced equally satisfactory results. In this case the pans are stacked above each other in suitable racks, upon which they are pulled through the leer.

These installations, while not large, have demonstrated the value of electric heat where exacting conditions have to be met, and it is stated by those in charge of this work that they would prefer the most accurate heat control obtainable, regardless of annealing cost, since the cost of annealing is only 1 to 2% of the value of the annealed ware.

(4) The most outstanding application of electric heat for annealing commercial glassware has been made by the Illinois-Pacific Glass Company at San Francisco. This Company has had electrically heated leers in operation for several years, beginning in a modest way and gradually extending, until in the very near future the entire output of their plant will be annealed electrically.

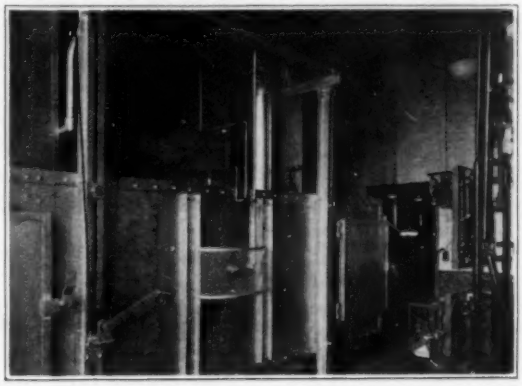

FIG. 4.

The product is bottles of various sizes and shapes, and the leers are of the usual horizontal travelling conveyor type, so that this plant is representative in product and equipment of many glass plants.

All the leers except the earlier ones are 9 feet usable width, and 17 inches clearance height. A total of nine leers are or soon will be in operation.

The heaters are located openly in the roof and on the side walls of the heating chamber, covering practically the entire inner wall surface, and are divided into four control zones along the leer. Heaters of adjustable capacity are also provided under the conveyor for a portion of the distance, and others are provided for preheating the conveyor before the ware is placed upon it.

The connected load is 240 kw., but the full power is never required except when starting up the leer. The heaters in the cooling zones are idle a large part of the time, but they come into action automatically in periods of light loading, so that they are always on guard to maintain the temperature curve to which they are set, regardless of the amount of ware going through.

Operating Results

From records that have been kept it is shown that the current consumed is well within the limits that might be expected, and the following data from a typical week's run may be of interest. The leer was run continuously 24 hours per day, 7 days a week, handling the output of two blowing machines, and was completely filled. The bottles annealed have a capacity of 16 ounces and weight of 12 ounces. This bottle has a fairly small weight per unit of area, and is typical of the product, although the heavier bottles can be annealed with somewhat less heat input.

During the week there were annealed 29,879 dozen and the total power consumed was 11,010 kwh.

For convenience this data is extended in the following table:

OUTPUT OF 9-FOOT LEER FOR SEVEN DAYS CONTINUOUS OPERATION

Bottles 16 oz. capacity—12 oz. weight.

Annealed during week 29,879 dozens or 2482 gross.

Total power consumed	11,010 kwh.
Kwh. per gross	4.43
Total weight annealed	273,500 lbs.
Lbs. per kwh.	24.85
Average lbs. per hour	1,625
Average kwh. per hour	65.5

Power Consumption This shows the average input and output, from which the cost of operation can be readily computed when the power rate is known. For example, at 1 cent per kwh., the power cost for annealing would be $4\frac{1}{2}$ cents per gross, or approximately 25 lbs. of ware can be annealed for one cent. This will vary with the size of bottles and density of loading. The output given above, namely 1625 pounds per hour, is considerably less than the capacity of the leer which can handle more than 2000 lbs. per hour.

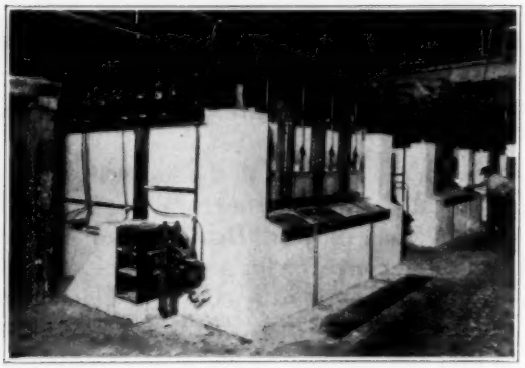

FIG. 5.

Figure 5 is a view of the entrance end of a group of these leers, and Fig. 6 is a view of the exit ends, showing the bottles being delivered and ready to be packed.

Labor Required These leers require no attendance whatever, except daily routine inspection of the control board and instruments for checking, oiling, reading meters, etc., which require an electrician's helper about one hour each morning for the eight leers.

Heating Units The heating units used in these leers are of heavy nickle-chromium ribbon. They are of extremely conservative design, and operate at a very low temperature gradient. Covering as they do practically the entire interior wall and roof surface, the heat liberated per square foot of surface is very small, thus providing a very mild and uniformly distributed source of heat supply.

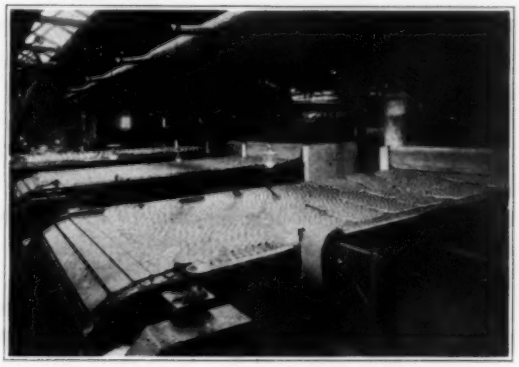

FIG. 6.

Maintenance Expense

Maintenance expense is entirely eliminated because the temperatures in all parts of the leer are so low. No deterioration of heating units, structural work, or conveyor is apparent.

Temperature Control The temperatures for the various zones along the leer can be set at the desired values, and are maintained automatically at the set values, so that if the correct annealing cycle has been determined, the ware will come from the leer thoroughly annealed and absolutely clean and sterile.

Design and Construction Factors

In the design and construction of leers of this type, there are several important factors to be borne in mind, such as adequate heat insulation, avoidance of air currents, etc. Wall and roof heat insulation of sufficient thickness is essential, through which no fire brick should be allowed to extend. Metal through the walls should also be avoided where possible, and where impossible to avoid it, it should be reduced to the minimum, and metals used which offer high resistance to heat flow. Note in Fig. 5 that the bearing support for the front sprocket shaft is located outside of a heavily insulated wall, only the shaft itself extending through the wall.

A circulation of air within the leer will not only distort the temperature curve, but if allowed to escape from the leer a considerable amount

of heat will be lost. The walls should therefore be tight, the doors close fitting, and allowed to be open only when ware is being put in. A tight partition, heat insulated where required, should extend horizontally the full width and length of the leer to prevent air currents flowing up through the conveyor.

Efficiency

The efficiency of these leers is in inverse ratio to the amount of ware being put through; therefore they will operate at higher efficiency at heavy loadings.

This is due to the fact that approximately the same amount of heat is required to preheat the conveyor regardless of the loading, and also because the heat put into the ware at the entrance end will be given up in the cooling zones, tending to supply the wall losses in these zones, therefore requiring less input to the heaters in these zones to maintain the temperatures.

Since the conveyor is usually cooled to room temperature at the exit end, and must be heated before ware can be again placed upon it at the entrance end, the efficiency could be somewhat increased if the conveyor were not allowed to cool to room temperature. For this reason it would be desirable to arrange to handle the ware at the exit end at as high a temperature as possible, in order that the conveyor may be returned while still hot, or if possible to transfer the ware after annealing to a second conveyor, which would carry it out into the room. The first conveyor would then lose only a part of its heat.

Capacity Possibilities

It should be pointed out that leers of this type can be built of any length, with any number of control zones, and to produce any desired temperature curve.

Furthermore, various temperature curves can be produced from time to time in a given leer to meet the requirements for different kinds of ware, or annealing cycles can be lengthened, shortened, or otherwise varied, remaining always under positive control.

The automatic control is responsive instantly to changing load conditions, and will draw from the heaters just enough to maintain the temperatures and no more, so that maximum economy under all loading conditions is automatically secured.

Two leers are now in operation which are much longer than those above described, and in which large and heavy ware is being annealed. These leers have eight control zones, and are doing with complete success a very difficult annealing job. The two leers replace four oil-fired leers, in which it had been impossible to secure satisfactory annealing of this product.

Leers for Plate Glass

Studies have been made of annealing leers for sheet and plate glass, and designs have been worked out which appear entirely practicable, although no applications have yet been made.

Leers for Optical Glass

The annealing of optical glass has always been a difficult process, due to the uncertainty of maintaining the correct cooling rates. With electric heat and suitable control equipment it is possible to control these rates with certainty, and to a large extent automatically, so that results can be duplicated time after time.

A furnace box 24 inches wide, 4 feet 6 inches long, 20 inches high, of the type shown in Fig. 7 has been in use for some months for annealing lenses and prisms. The parts are suitably packed in cast iron boxes, and the furnace chamber is nearly filled with the boxes. The boxes combined with the fire-brick lining of the furnace afford a considerable mass and heat storage capacity which has the effect of delaying the rate of temperature changes in the glass.

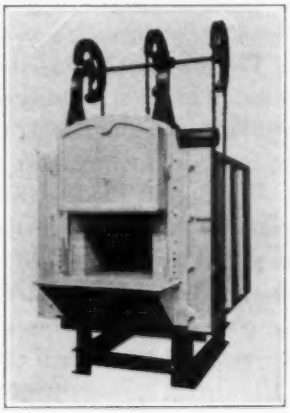

Fig. 7.

The furnace is provided with a high heat connection of 40 kw. for use in heating the charge, after which the heaters are put in low heat connection for the holding and cooling portions of the cycle. The low heat connection is further provided with a series of taps, by means of which the input can be adjusted to lower values in moderate steps, and a curve drawing automatic control instrument with time-rate attachment is employed to maintain the temperature and to lower the control point at the desired rate.

Control is obtained by automatically changing the connection of the heaters from one tap to the next lower and back again in response to slight temperature changes as indicated by a sensitive thermocouple in the air of the furnace, so that the heat is never thrown entirely off except on the very lowest tap. Note that control is obtained from the air of the furnace which gives quick response, and not from the mass of the charge.

The input is adjustable in five steps, which adjustments are made by hand from time to time during the run, and the following combinations are thereby secured:

Step no.		1	2	3	4	5
Kw. input	High	13	11.5	9.7	6.4	3.25
	Low	8.2	6.4	4.9	3.25	Off

On step number 1, the control throws back and forth from 13 kw. to 8.2 kw. and after a suitable time has elapsed the connections will be changed manually to step number 2, and so on, the time-rate controller gradually lowering the temperature at the desired schedule.

This apparatus has been found to give excellent results, and there is no reason why the same principles cannot be applied generally to the annealing of optical glass.

Leers for Telescope Disks

A careful study has also been made of the problem of annealing large glass disks for telescopes. As is well known, the requirements for this work are exceedingly exacting.

The problem as stated requires that the electric furnace should receive a batch of 4500 pounds of molten glass, held in a cylindrical refractory crucible weighing 3000 pounds, which, after solidifying, should be cooled to room temperature at certain specified rates.

When cold the pot would be stripped off and the cylinder of glass placed again in the furnace, held in a mold of the diameter and shape required for the finished disk. The temperature would be raised to melt the glass and allow it to take the shape of the mold, after which it would be cooled to room temperature, both the heating and cooling rates to be carefully controlled through part of the cycle.

The disk would then be ground to exact size and shape, and returned to the furnace for the final anneal, supported in a cast iron mold into which it would fit exactly. The temperature should be raised at a rate not to exceed 2°C per hour to the annealing temperature, which when reached should be maintained with no variation whatever for a period of 30 days, then cooled at the rate of $\frac{1}{10}$°C per hour to a certain temperature after which the rate could be somewhat increased.

An outline of the furnace in which it was proposed to carry out these cycles is shown in Fig. 8, in plan and longitudinal section. The furnace chamber is cubical, and is provided with heaters of equal capacity on all six sides. The disk is located at the center of the chamber. The inside walls are made heavy to provide heat storage capacity and are exceptionally well insulated, both of which features will tend to make temperature changes occur at a very slow rate.

Each group of three heaters, on each of the six sides of the furnace, would be provided with a suitable combination of shunted rheostats, so that the input to each heater could be individually and minutely adjusted, and thus the temperature from the top to bottom or from side to side. This balancing of input will eliminate convection currents

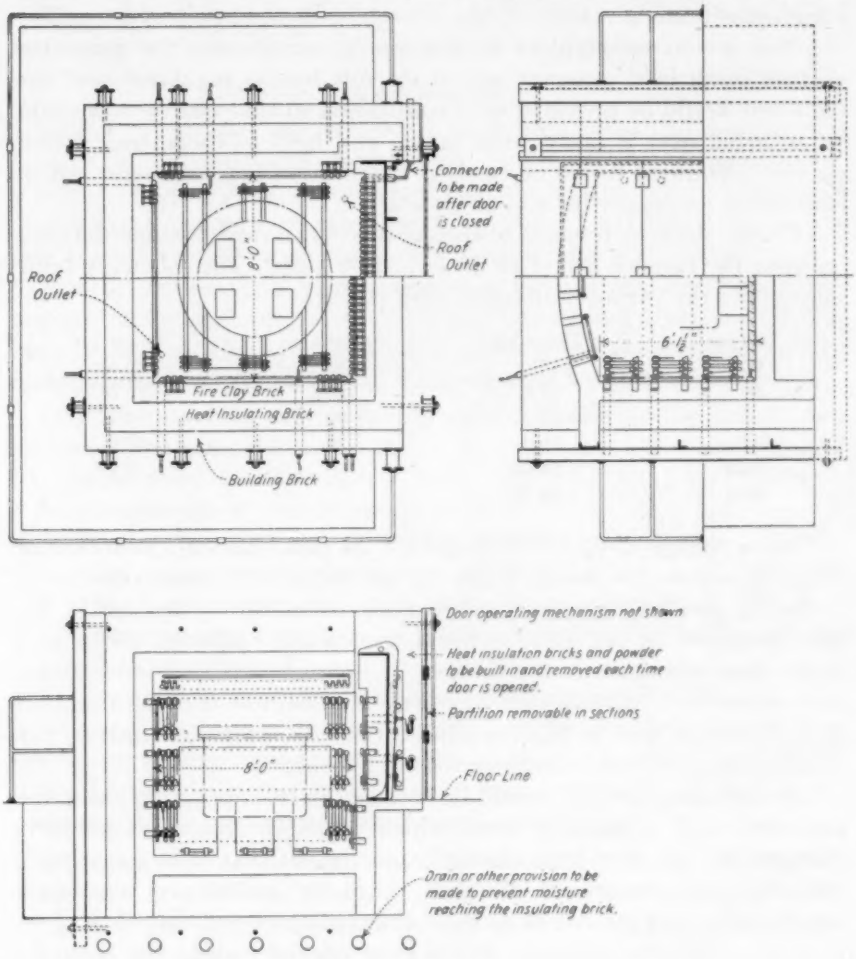
Connection to be made after door is closed
Roof Outlet
Roof Outlet
8'-0"
Fire Clay Brick
Heat Insulating Brick
Building Brick
6'-½"
Door operating mechanism not shown
Heat insulation bricks and powder to be built in and removed each time door is opened.
Partition removable in sections
8'-0"
Floor Line
Drain or other provision to be made to prevent moisture reaching the insulating brick.

FIG. 8.

within the chamber since such currents have their origin in differences of air temperature.

The adjustments would all be made manually, from indications of a number of calibrated thermocouples distributed through the furnace, which would be read on a precision potentiometer. When once adjusted

for equal temperature distribution, comparatively few subsequent adjustments would be necessary.

The temperature of the furnace would be raised, lowered, or held constant by means of accurate voltage control, a supersensitive form of voltage regulator being employed which would hold the voltage constant within $\frac{1}{10}$ volt.

Power would be supplied by a motor generator set, the generator voltage being held constant within $\frac{1}{10}$ volt by the regulator, and the regulator would be provided with calibration so that the voltage could be adjusted over a fairly wide range, and held to its setting within $\frac{1}{10}$ volt. Voltages would be read on a deflection potentiometer, which instrument can easily be read to $\frac{1}{10}$ volt.

To show the sensitiveness of this method of control, assume that the input to the furnace would be 18 kw. at 90 volts. The following table then shows the variation of input with voltage:

Voltage	Input kw.	Voltage	Input kw.
90	18	86.7	16.68
89	17.6	86.6	16.65
88	17.2	80	14.2
87	16.8	70	10.9
86.9	16.76	60	8.0
86.8	16.72		

Thus a change of $\frac{1}{10}$ volt will change the input only .03 to .04 kw. or 30 to 40 watts, the power taken by an ordinary incandescent lamp.

During the holding and cooling portions of the cycles, all of the heat generated by the resistors will flow outwardly through the furnace walls, since none goes to the charge. The action of the heaters on each unit of interior surface is then to supply the heat loss through that unit of wall surface and as has been indicated, the individual heaters can be accurately adjusted to accomplish this result.

Furthermore, the disk would be enclosed in its supporting mold and provided with a massive cover which tends to retard temperature changes due to their heat storage capacity, so that it is conceivable that the temperature of the disk could be maintained absolutely constant for long periods of time, or changed at exceedingly slow rates, if it is possible to maintain inputs even approximating the accuracy indicated.

It would also be possible to locate the furnace in a closed room to further reduce changes of wall temperature, due to air currents or atmospheric changes.

The motor generator set for supplying power should be supplemented by an engine driven set, for use in case of failure of the usual source of supply.

While it is realized that an equipment as outlined may be considered elaborate, the value of a disk when ready for the final anneal is many times the cost of the annealing apparatus, and it would therefore seem advantageous to employ the best equipment obtainable within a reasonable cost.

The suggestions are offered with the hope that they may be of assistance in the building of better lenses for telescopes.

Conclusions

While the installations referred to have been chosen to show a wide variety of applications of electric heat, ranging from the annealing of bottles to optical glass, it is realized that the manufacture of bottles is a very large and important industry, in which a saving in the cost of manufacture would represent a very considerable economic gain.

The results of several years of operation have shown that substantial savings in the cost of manufacture can be realized and that electric heat is particularly well adapted to travelling conveyor leers. The reasons previously set forth may be summarized as follows:

1. Ware perfectly and uniformly annealed, eliminating rejects and increasing output.
2. Ware clean and sterile.
3. Elimination of attendance.
4. Elimination of or greatly reduced maintenance.
5. Mild and uniformly distributed source of heat.
6. Automatic control maintains exact temperature curve.
7. Temperature curve can be adjusted to any desired values for different kinds of ware.
8. Correct temperatures maintained regardless of loading.
9. Possibility of shortening annealing cycles due to accurate temperatures, thereby using shorter leers, saving in cost and floor space.
10. Extremely desirable load from the standpoint of the power company, being continuous and of high power factor.

Acknowledgment is made of the assistance of W. M. Clark, National Lamp Works, Cleveland, and K. M. Henry, Illinois-Pacific Glass Co., San Fancisco, and other use of data which they have submitted.

OIL FIRING, ITS LIMITATIONS AND ADVANTAGES[1]

By L. A. Mekler

ABSTRACT

The most common types of fuel burning equipment and the usual methods of their installation, originally developed and perfected for power plant use, are not suitable

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Heavy Clay Products Division). Received January 6, 1926.

for the ceramic industry and result in excessive costs and difficulties in operation and control. When fuel oil is considered not a substitute for coal but an independent fuel with characteristics somewhat radically different from those of coal, and the kiln construction together with method of firing is changed to meet these characteristics, oil firing proves superior to coal firing in nine cases out of ten.

Oil firing is one of the newest tools of the ceramic industry and probably the least properly used. With the exception of a few plants that spent considerable time and money to adapt oil firing to their needs and the construction of their kilns, the industry as a whole spends from one and one-half to two times as much for fuel and kiln upkeep as it should and would if proper care were taken in the choice of equipment, its installation, and operation.

The greatest drawback to successful and therefore more universal application of oil firing in the ceramic industry is the fact that the average kiln and the most popular types of oil firing equipment, particularly the burners, are not suited to each other. The kiln, irrespective of its type, is a coal firing heating apparatus with a predetermined firing cycle and constantly increasing temperatures which at the end of the firing exceed 2000°F. The oil burning equipment, originally developed for boiler firing and only recently transplanted but not fully adapted to other uses, is mainly designed to produce a constant supply of comparatively low temperatures. The kiln obtains its heat from a large number of small fire boxes each supplying a small portion of the total. In a boiler all of the heat is supplied from one fire box volumetrically almost twice as large as the heating chamber proper. An average kiln fires best with a long flame. Oil naturally is a short flame fuel. A long flame heats mainly by radiation, as it is highly luminous. The amount of heat transferred from a luminous flame to the material is determined by the difference in temperature between the flame and the material heated (Stefan-Boltzman Law). A short, non-luminous flame heats mainly by convection. Its heating capacity depends greatly on the velocity with which the gases of combustion strike the heated material, even more so than on the temperature difference.

Oil is a very intense fuel and has practically no intermediate combustion from C to CO_2 as is characteristic of coal burning as practiced in kiln firing. All of the heat value of the oil burned is developed in the fire box and not distributed for quite a distance through the kiln itself. Since no provisions are made for increased velocities of the gases of combustion through the kiln or for their immediate discharge from the fire boxes as they are formed, the average kiln newly converted to oil has usually much higher fire box temperatures than it had with coal, with the result that even without the slagging action of the coal ashes the fire boxes, kiln bottoms and the refractories near the fire boxes last

considerably less with oil than with coal. Most of the plants converted to oil by merely pulling out the grates from the fire boxes and inserting any kind of a burner in the fire box front have this as their main trouble.

The usual remedy against excessive fire box temperatures is to open the front of the fire box "to cool it off" with a large excess of air. While this does cool the fire box it increases the volume of the gases passing through the kiln, reduces their velocity and therefore decreases the amount of the heat they can give off before they leave the kiln. The stack losses, the greatest losses in periodic kiln firing, become even greater on account of the higher stack temperatures, and the efficiency of the kiln, low as it is, is thus further reduced. This is shown by the comparison of the oil consumption and the amount of coal previously used. On the B. t. u. content one ton of average coal used for kiln firing is equivalent to about 156 gallons of 20–24° Baumé oil. Most plants converted to oil use in the neighborhood of 200 gallons. In addition to lowering of the efficiency of the kiln, the excess air used for the "cooling off" and the resulting increased volume of the gases disturb the usual regulation of the kiln. Heat begins to hang around the fire boxes and either the bottom or the crown of the kiln with the result that the kiln cannot be finished properly unless the method of loading is changed.

The average oil-fired kiln is operated under highly oxidizing conditions throughout the firing period. While most ceramic materials require an oxidizing atmosphere through the "oxidation period" of the body and the glazes, the average oil-fired kiln is much more oxidizing than it is necessary or than a coal-fired kiln would generally be. Coal firing produces a truly oxidizing flame only for a short period before the addition of a new charge of coal. Just after the coal is added the atmosphere is highly reducing and for the most of the time it is neutral. A highly oxidizing atmosphere as produced in an average oil-fired kiln facilitates the oxidation of the different compounds to the "ic" (such as "ferric") state, which are as a rule much more refractory than the "ous" (such as ferrous) compounds formed under reducing or neutral conditions. It is, therefore, not uncommon to find that an oil-fired product is less mature even though fired to the same temperature as the coal-fired one. This is particularly true with the heavy clay industries using an unprepared clay naturally rich in iron, and is demonstrated by the difference in texture and color of the coal- and oil-fired article.

The last but not always the least objection to oil firing is the cost. Because of the large excess of air used and the higher stack temperatures usually produced, a newly converted plant spends from 20 to 50% more for oil than it used to spend for coal, the average being from $7.50 to

$10.00 in oil costs for each ton of coal previously used. Even with the savings of coal and ash handling and the reduction of the labor cost of firing, the balance is still in favor of coal unless improved quality and increased capacity result in greater savings than the difference in fuel and kiln upkeep costs.

But just because oil firing conditions as they exist in most plants converted to oil show all the disadvantages described above, it does not mean that when properly installed and adapted to the requirements of the firing process and the kiln construction, in nine cases out of ten, oil will not prove a better fuel than coal for kiln firing.

Oil is a much more flexible fuel than coal. With oil any predetermined firing cycle can be very closely followed. Ceramic bodies are greatly susceptible to thermal treatment and their physical properties are affected by the rate of heating as well as the temperature to which they are fired. At transformation points of the constituents the rate of heating is particularly important. With oil a turn of the valves will give any rate desired and keep it without variation for any length of time; something impossible to do with coal.

An oil-fired plant is much cleaner than one firing with coal. There are no coal or ash heaps around the kiln or coal and ash dust in the air. A certain floor and wall tile plant after converting the kilns to oil firing does all the dipping in the kiln shed, with the dipping machines not six feet away from some of the kilns. This means not only the saving of the space previously occupied by the machines elsewhere, but a saving in loading costs as well, since now the ware is within an arm's reach from the doors of some of the kilns, while with coal it had to be carried for over 200 feet from the adjoining shop.

Oil firing is cleaner chemically as well as physically. A properly operated suitable burner will not smoke from the start. Oil leaves no mineral residue after burning and there is no danger of any ash dust depositing on the material and fluxing with the glazes. Even the highest gravity fuel oil contains less sulphur per B.t.u. developed than the average best kiln coal used. The chemical composition of the gases of combustion is also much more easily controllable with oil than it is with coal. Therefore the means of protection of the ware from contact with the flame usually employed with coal (muffles, saggers, etc.) are not as necessary with oil. An electric porcelain manufacturer, after converting the plant to oil, fires all the large pieces in the open fire on top of the regular bungs. The ware looks even better than when fired in saggers with coal. A terra cotta manufacturer made three successful experimental firings of terra cotta in the open flame, firing some of the so-called tricky colors and glazes without apparent damage to the body, the color, and the glazes. The terra cotta was fired in a Canon furnace,

but the electrical porcelain and the tile are being fired in an ordinary kiln with a standard low pressure burner.

The ease with which any rate of firing can be maintained with oil results in a shorter firing period. A 25% saving in firing time is not uncommon, while with quick firing operations like glost firing, the firing period is cut almost in two. This means faster turnover and increased production with the same kilns, or a slower and more careful cooling of the ware with the same turnover of the kilns. The latter is very important where large pieces are made since a slower cooling reduces the amount of ware cracked in the kiln and by somewhat annealing the pieces makes them mechanically stronger. In one plant after the installation of oil firing equipment and the extension of the cooling period by the number of hours saved on the firing, dunting and kiln cracking were practically eliminated. This saving alone amounted to three times the difference in fuel costs between coal and oil.

Quite a number of ceramic plants are located within the city limits of industrial towns where real estate is of considerable value. An oil-fired plant has no unproductive space occupied by the coal pile and the ash dump. The oil storage tanks are usually buried underground. The space above them can be used for material storage, assembly, inspection or other manufacturing operations which do not require heavy or special machinery, thus relieving space somewhere else which can be utilized much more profitably.

The oil industry is more stable than the coal industry. An oil-fired plant using over 100,000 gallons of oil per year and able to buy the oil in tank car lots, can buy the fuel on contract and be assured of uninterrupted supply of fuel at a predetermined maximum price for the next six months. The quality of his fuel, once decided upon, is also constant, particularly if the contract is made with a refinery and not a broker handling the product of several refineries, sometimes not even in the same production field. Therefore an oil-fire-plant does not have to carry a large supply of fuel on hand. In many cases the cost of the oil tanks, pumps, etc., is paid by the savings in the capital investment represented in an average coal pile.

Even the higher fuel costs with oil as compared with coal are not without exception. At plants that have adapted their kilns to oil firing and intelligently use a type of equipment most suitable to the basic construction characteristics of the kilns and the firing operation, the fuel cost per unit of ware produced is lower than it was with coal. While the B.t.u. equivalent is about 156 gallons of oil per ton of coal, the actual ratio of coal to oil previously used is about 125 gallons per ton. Inherently the kiln is a very inefficient heating apparatus, particularly in the method of generation of the heat. With oil the efficiency of heat

generation is much higher than it could be with coal. A shorter firing cycle which reduces the total stack losses contributes farther to higher efficiency. When the efficiency of application of heat with oil firing is increased by the proper design of the fire boxes, so that the heat is released into the kiln as soon as it is developed, by proper damper regulation, by adjustment of the firing rate at different periods of the cycle, by the reduction of the excess air to a minimum, the ratio of oil to coal can be reduced to as low as 100 gallons per ton of coal previously used. Most ceramic plants can buy fuel oil for 5 cents per gallon at the tip of the burner. The oil costs per ton of coal previously used could therefore be between $5.00 and $5.50. This compares favorably with the actual cost of coal at the kiln plus the cost of ash handling, particularly if the wages of the fireman's helper, who is not necessary with oil firing under the ordinary plant conditions, are taken into account.

The present prevailing practice of firing ceramic materials by burning solid fuel in a large number of small fire boxes, which in reality are very crude gas producers, is the survival of the times when no better method of producing heat was known. It is wasteful, dirty, hard to control and is adhered to because of the natural conservatism of the human race. The substitution of oil for coal and a burner for the grates without any further changes in the construction of the kiln or the method of its operation,—in many cases instead of an improvement over the old method, results in a bad case being made worse. It is only when oil will be considered not as a substitute of coal but as a fuel with its own peculiarities and its own methods of application, will the limitations discussed here disappear and all the advantages will demonstrate themselves to the greatest extent.

Consulting Combustion Engineer,
24 Pennington St.,
Newark, N. J.

THE PERMISSIBLE MOISTURE CONTENT IN BALL CLAY SHIPMENTS

By Arthur S. Watts[1]

This Committee was created by popular vote of both shippers and buyers and its mode of procedure was also determined by a questionnaire sent out to both shippers and buyers.

The committee is as follows: R. W. Greene, Kentucky Constn. & Imp. Co., Mayfield, Ky.; Geo. Simcoe, Edgar Plastic Kaolin Co., Metuchen, N. J.; Geo. Brian, East Liverpool, Ohio; A. V. Bleininger, Homer Laughlin China Co., Newell, W. Va.; Paul Teeter, Trenton Potteries Co., Trenton, N. J.; J. D. Whitmer, American Encaustic Tiling

[1] Ball Clay Data Committee, White Wares Division.

Co., Zanesville, Ohio; A. S. Watts, Ohio State University, Columbus, Ohio.

The mode of procedure was determined by a majority vote and is as follows:

(1) The normal water content shall be determined by actual tests on samples of wet, normal, and dry ball clays.
(2) The samples to be tested shall be obtained from the consumer without consulting the shipper.
(3) Ball clays shall be classified on both a raw color and a viscosity basis.
(4) Foreign and domestic ball clays shall have separate classifications.

The vote was conclusive on all questions except No. 4 in which those favoring separate classifications for foreign and domestic clays had only a small majority.

In order to determine the practicability of this procedure the writer secured ten samples of very wet ball clay, four being English and six American.

These clays were tested for moisture content as received, then made into 1 pound balls, dried for 2 days in an unheated room, (temperature average 78°F) and tested for moisture content, and finally dried for 10 days more in the same room and again tested.

The figures obtained are as follows:

Ball clay	Wet, % water	Medium, % water	Dry, % water
Dark English	32.5	24.0	11.7
Dark "	39.0	27.0	14.0
Mixed "	31.0	25.5	13.0
Mixed "	35.0	25.0	12.0
Dark American	30.5	20.5	14.0
Dark "	33.0	21.5	11.5
Medium "	32.0	22.0	12.0
Light "	28.5	19.5	9.5
Light "	31.5	19.0	9.0
Light "	29.0	21.0	10.0

These balls were tested several weeks later and due to warmer weather which prevailed had lost about 3% water in all cases. The rapid drying evidenced by these clays cannot be taken as any evidence of what would occur under normal storage conditions as the balls were small and were surrounded by conditions favorable to drying.

All these samples of wet ball clay had been exposed on stock piles during the winter of 1924 but were not uniform in regard to water content because some were dried due to favorable weather while others had been rained on just before the samples were taken.

If the evidence obtained from these tests can be taken as typical, it appears that English ball clays will take up more water when exposed to rain and release it more gradually than American ball clays and also

that the light colored clays carry less water when medium dry than the the dark colored clays, although this is less evident in the English ball clays than in the American clays.

Attempts to use the viscosity of the ball clays as a basis for classification were very unsatisfactory. The samples were all first dried at 105°C and pulverized and were then ground for one hour with four times their weight of distilled water and the viscosities of these clay-water mixtures were determined by a Marriatt tube flow viscosimeter. The viscosity values of the clays were not in the order expected and some light clays produced more viscous mixtures than the dark clays. Council with others has confirmed my personal opinion that ball clays, if oven dried, never behave in the same manner as when tested without drying, or if only moderately dried. An attempt to establish some relationship between the viscosity of ball clays and their other properties soon convinced me that this is a problem even greater than the one before us and has no direct bearing on the question before this Committee.

The next step in the study was to obtain from as many sources as possible, samples of ball clay in the condition received and to determine the moisture content of these and other data which may prove useful in formulating specifications to govern permissible moisture in ball clay shipments.

The following data is offered:

Very Dark English Ball Clay With 28% water content, this clay will cut with a knife without sticking and can be molded into a ball by light tamping; with 24% water content this clay can be broken with a maul and cannot be molded into a ball except by power pressure; with 20% water it seems commercially dry.

Mixed English Ball Clay With 25% water content, this clay will cut with a knife without sticking and can be molded into a ball by persistent working in the hands, without tamping; with 21% water content this clay can be broken with a maul and cannot be molded into a ball by working in the hands; with 18% water it seems commercially dry.

Light English Ball Clay With 20% water content this clay will cut with a knife without sticking and can be molded into a ball with the hands; with 17% water content this clay can be broken with a maul and will not stick together when molded in the hands; with 14% water it seems commercially dry.

Dark American Ball Clay With 25% water content this clay cuts with a knife with a slight tendency to stick, and molds readily into a ball in the hands; with 20% water content this clay can be broken with a maul and cannot be molded in the hands; with 16% water it seems commercially dry.

Dark American Ball Clay With 22% water content, this clay cuts with a knife without sticking and molds into a ball in the hands; with 18% water content this clay can be broken with a maul and cannot be molded in the hands; with 15% water it seems commercially dry.

Gray American Ball Clay With 24% water content this clay cuts with a knife without sticking and molds with difficulty into a ball in the hands; with 20% water content it can be broken with a maul and will not mold in the hands; with 16% water it seems commercially dry.

Gray American Ball Clay With 19% water content, this clay is slightly too wet to be broken with a maul; with 16% water content it seems commercially dry.

Cream American Ball Clay With 21% water content, this clay cuts with a knife without sticking; with 18% water it breaks readily with a maul; with 15% water it seems commercially dry.

Data on shipments of American ball clays furnished in coöperation with this investigation indicate that on weekly shipments over a period of one year, one shipper only exceeded 21% moisture content on one car and no car carried less than 17½%. This was on a gray ball clay.

On shipments of a dark ball clay, March to September, the moisture content varied from 24½ to 27½%.

On a light ball clay the moisture content varied, February to September inclusive, from 5 to 13½%, but during October averaged 21%. Another ball clay varied from 11 to 16% during 3 summer months.

I recognize that this is not sufficient data on which to base a final statement but I know that these clays are all typical of large deposits and are similar to shipments received by many American factories.

The evidence indicates that dark ball clays carry more water for the same appearance of wetness than light ball clays and that with 25% water content a dark ball clay can be worked in a disintegrator. With 20% water content a dark ball clay can be broken with a maul. With 16 to 18% water content a dark ball clay may appear commercially dry.

A light ball clay carries less water for the same apparent condition of wetness.

The evidence indicates that English ball clays carry more water than American ball clays.

While it is generally agreed that ball clays may be injured by being completely dried, we have no evidence to justify an excess water content and the practice of paying freight on 35% water or buying extremely wet clay must sooner or later be adjusted. If a manufacturer prefers wet clay the shipper can doubtless supply his wants, but if the manufacturer prefers to pay for clay on 10% water basis it seems reasonable that his demands should be considered, provided they are not unreasonable. The purchaser must expect to pay a premium for dried clay however, the same as he pays a premium for extra fine ground feldspar or flint. It is not the purpose of this investigation to impose hardships on either shipper or consumer but to find if possible a reasonable basis for adjustment of this controversy. If those concerned cannot find some means of transacting business on the basis of actual clay content of the shipments, then the most reasonable system is the establishment of a Permissible Moisture Content which will be accepted by the consumer. If such limits are established, however, it would seem reason-

able that the shipper should have credit if he reduces the moisture content below the amount specified and should suffer a deduction if he exceeds the permissible water content. If the presence of a certain water content is beneficial then we should establish a minimum permissible water content as well as a maximum permissible water content.

Without pretending to represent any group and without obtaining a vote from the committee which is studying this subject the writer begs to suggest for your consideration the following, which he thinks would not be injurious to the clays or unjust to the shipper.

Ball clay	% Maximum permissible moisture
Dark English	22
Medium "	20
Light "	18
Dark American	20
Medium "	18
Light "	16

The minimum permissible moisture content shall be 50% of the maximum and adjustments for shipments carrying moisture between maximum and minimum shall be provided for on the same basis as the adjustment which shall be provided for in case the moisture content exceeds the maximum permissible amount.

Any arrangement other than these must be by special agreement between shipper and purchaser.

LORD HALL, O. S. U
COLUMBUS, OHIO

ACTIVITIES OF THE SOCIETY

NEW MEMBERS RECEIVED FROM APRIL 16 TO MAY 15

PERSONAL

Henry N. Bauman, Jr., 657 E. 42 St., Seattle, Wash. Graduate Student, Univ. of Wash.

John Henry Burn, 32 Mosley St., Newcastle-on-Tyne, Eng. Manufacturer of Refractories.

Hobert Reed Goodrich, Box 316, Lompoc, Calif. Ceramic Engineer, Celite Products Co.

H. H. Holscher, 1201 W. Springfield St., Urbana, Ill. Student, Univ. of Illinois.

Harry B. Lindsay, Norton Company, Worcester, Mass. Sales Manager, Refractories Division.

H. T. Meyer, 309 E. John Street., Champaign, Ill. Student.

Frank E. Oettinger, Box 672, Lompoc, Calif. Foreman Insulating Brick Plant, Celite Company.

William J. Purnell, 5601 So. Boyle Ave., Los Angeles, Calif. Supt. Atlas Fire Brick Co.

Dorothy James Smith, Edgewood School, Greenwich, Conn. Teacher of Pottery and Designs.

Wm. P. Stoll, 625 Market St., San Francisco, Calif., Roessler & Hasslacher Chemical Co.

Hans Untucht, Lieverstorstr, 51 Magdeburg, Germany. Chemist.

CORPORATIONS

Coral Ridge Clay Products Co., 1522 Inter Southern Bldg., Louisville, Ky. Jas. T. Howington, Representative.

Verreries Souchon Neuvesel, Givors (Rhone) France.

West Gas Improvement Co., 441 Lexington Ave., New York, N. Y., F. J. Kennedy, President.

Membership Workers' Record

	Personal	Corporations		Personal	Corporations
Chas. F. Binns	1		C. W. Saxe	1	
H. T. Coss	2		Clement Saxton		1
F. T. Heath		1	Clifford Tillotson	1	
W. Malsch	1		Hewitt Wilson	1	
Percival Marson	1		Office	1	1
T. N. McVay	2				
			Total 14	11	3

PERSONAL NOTES OF MEMBERS

L. L. Beeken, formerly employed with the Jeffery-Dewitt Insulator Co., Kenova, W. Va., is now with the Trenton Potteries Co., Trenton, N. J.

A. E. Blake has been transferred from the Pittsburgh District to Philadelphia by the U. G. I. Contracting Co. His present address is 1115 Dickinson Road, W. Brookline, Upper Darby Post Office, Pa.

Ernest W. Daily, who has been connected with the Russell Engineering Co., St. Louis, Mo., has removed to 412 First St., N. W., Mason, City, Iowa.

J. Earl Frazier has recently accepted a position as chemical engineer with the Simplex Engineering Co., Washington, Pa. Mr. Frazier was formerly with the Berney-Bond Glass Co., Clarion, Pa.

F. A. Harvey is now with the Harbison-Walker Refractories Co., Pittsburgh, Pa. Dr. Harvey was formerly associated with the United States Refractories Corp., Mount Union, Pa.

Joseph C. Hearn is situated with the General Rustproof Co., Long Island City, N. Y.

F. G. Jackson, who for the past four years has been chemist for the Ceramic Station, U. S. Bureau of Mines, Columbus, Ohio, has recently resigned to take up consulting work in ceramics and chemistry.

Robert M. King has accepted a position in sales engineering work for the Wellsville Fire Brick Co., with headquarters in St. Louis, Mo. Mr. King's, address is 5073 Cabanne Ave., St. Louis, Mo.

William V. Knowles of the Titanium Alloy Mfg. Co., has been transferred from Chicago to the Cleveland office of that Company, at 6007 Euclid Ave.

Gordon S. Lindsey has recently moved to 137 East Grand Blvd., Detroit, Mich., from Pittsburgh where he has been an Industrial Fellow at Mellon Institute.

William E. Magill has moved from Royerford, Pa. to 1740 Norwood Ave., Baltimore, Md.

David W. Miller is situated with the Fulton Fire Brick Co., Fulton, Mo., as ceramic engineer, having recently left the Ironton Fire Brick Co., Ironton, Ohio.

C. E. Parmelee of the Pittsburgh Plate Glass Co., has been transferred from Crystal City, Mo., to the plant at Creighton, Pa.

Wm. Reynolds, formerly employed with the Scranton Enameling Co. Scranton, Pa., is in charge of the Richardson and Boynton plant at Dover, N. J.

H. H. Stephenson, recently of Chattanooga, Tenn., is now with the Vitro Mfg. Co., Pittsburgh, Pa.

Hugh E. Weightman has moved from Ferguson, Mo., to 6802 Dorchester Ave., Chicago, Ill. Mr. Weightman is technical advisor to the Chicago Fire Brick Co.

Summer Meeting in Philadelphia

A definite date has not yet been set for the Summer Meeting of the AMERICAN CERAMIC SOCIETY. This meeting will be held in Philadelphia in order to permit members to attend the Sesquicentennial Exposition which will be in progress during the summer months. As soon as a definite opening date for the Exposition is made, plans for the Summer Meeting will be consummated and suitable announcements made to the members of the SOCIETY.

REPORT OF COMMITTEE ON RULES

At a meeting of the Committee on Rules held Monday evening, February 8, it was unanimously voted to submit the following recommendations to the SOCIETY, W. A. Hull having submitted a written opinion coinciding with that of the members present.

1. While there are a few desirable features in connection with the matter of a distinctive or honorary group of members, there are also difficulties which are not easily to be adjusted at the present time, such as outlining the proper qualifications, establishing a basis of selection, determining the advisability of special privileges as to holding office, and in voting, etc., and the Committee on Rules therefore recommends that this matter be held in abeyance until the next Annual Meeting and in the meantime be given further study and thought by both the Board of Trustees and the Rules Committee.

2. In view of criticism of the present method of nomination of officers and of the majority of the Committee on Rules holding the opinion that improvements can be made

over the present method, the subject of the Nominating Committee was given careful discussion and it was unanimously agreed to recommend that the rules of the SOCIETY be changed to read as follows:

There shall be two nominating committees selected at each annual convention. Such committees will each consist of seven members, one from each Division of the SOCIETY, and each will prepare an independent ticket of nominations to be submitted to the SOCIETY for ballot.

The members of the Nominating Committees will be selected as follows: At the final session of each Division two members of that Division will be elected to the Nominating Committee. These two will draw to determine which shall be on Committee No. 1 and which on Committee No. 2. The names and designations of these elected members of each Division will be immediately reported to the Secretary by the Chairman or acting Chairman of each Division.

Each nominating committee will be notified of its membership by the Secretary and each Committee will at once appoint its own Chairman and proceed to the nomination of officers for the ensuing year.

There are no restrictions as to the makeup of the two tickets and the same or different names may appear upon the two slates.

PROPOSED AMENDMENT TO CONSTITUTION

All papers, discussions and other writings which may be of interest or value to the SOCIETY if published, and which have been presented to a general session of the SOCIETY, shall become the property of the SOCIETY and their publication and other disposition shall be in the hands of the Committee on Publications.

No paper, discussion, or other writing which may be of interest or value to the SOCIETY if published which has been presented before a Division or local Section shall be offered for publication elsewhere until the Committee on Publications shall have had the option of accepting the same for use in the *Journal of the American Ceramic Society*.

No committee reports prepared by a committee of the SOCIETY or of a Division or local Section shall be offered for publication elsewhere until the Committee on Publications shall have had the option of accepting the same for use in the *Journal of the American Ceramic Society*.

GLASS DIVISION, COMMITTEE ON STANDARDS, ACTIVITIES

As a preliminary step toward the standardization of methods of analysis of glass and glass making materials, a standard sample of glass is being prepared by the Committee of Standards of the Glass Division of the AMERICAN CERAMIC SOCIETY.

This sample will be sent to any chemist, glass laboratory, or glass technologist upon request. It is understood that the results of the analysis are to be reported to the Committee who will treat them as confidential. The average of all results will be sent to those reporting. In this way no names will be given or published and each analyst will be able to check his work with that of a great number of others.

In this way the actual need for standard methods will be determined. It is requested that all who are able to do so, will send in their methods of analysis for sand, soda, lime, and glass. Several of the largest glass companies and consulting laboratories have signified their willingness to give out their methods of analysis. "Quick methods" are also desired.

Requests for samples and the methods of analysis should be sent to A. R. Payne, Hazel-Atlas Glass Company, Clarksburg, W. Va.

O. W. RENKERT IS AMERICAN CERAMIC SOCIETY REPRESENTATIVE ON PAVING BRICK SIMPLIFICATION COMMITTEE

In behalf of the National Paving Brick Manufacturers Association, the Engineering Profession, the Chamber of Commerce of the United States, and the U. S. Department of Commerce, we desire on this occasion to express our hearty appreciation and thanks to the members of the Standing Committee on Paving Brick Simplification (representing as they do technical, research and professional organizations and societies) who have, for the past five years, travelled varied distances at their own expense to actively participate in the deliberations of the Committee. This manifestation of interest in mutual welfare and devotion to the duties assigned them, and the placing at the disposal of the committee their expert technical knowledge, counsel and experience is, in a large measure, responsible for the singular progress and success of the Paving Brick Simplification program. As an example of constructive action by an industry and its allied interests, this Committee's work stands preëminent in the new order of self-government in American business.

(Signed) EDWARD E. DUFF, Jr., *Secretary*,
National Paving Brick Mfrs. Assn.
E. J. MEHREN, *Chairman*
P. E. HOLDEN,
Chamber of Commerce of the U. S.
R .M. HUDSON, *Chief*,
Division of Simplified Practice.

NOTES FROM THE LOCAL SECTIONS

Ceramic Day at Association of Chemical Equipment Manufacturers' Exhibit

The Northern Ohio Section held a meeting Thursday, May 13, at the Hollendon Hotel, Cleveland, Ohio, in connection with the National Chemical Equipment and Progress Exposition. Papers were presented by A. E. Marshall on "Glass", H. E. Ebright on "Refractories", M. A. Knight on "Stoneware", and R. G. Cowan on "Ceramic Art". In the evening an informal banquet was held. C. D. Cushman was Chairman of the Committee. About 100 members attended this meeting.

Detroit Section Elects

At a recent meeting of the Detroit Section, the following officers were elected: A. P. Ball, Chairman, Robert Twells, Vice Chairman, W. A. Carter, Secretary, F. H. Riddle, Councillor, and H. F. Royal, Member Nominating Committee.

Chicago Section Meeting[1]

A meeting of the Chicago Section was held on April 17, at the Great Northern Hotel. Following luncheon a short business meeting was held and a program of four fifteen-minute talks given: Mr. Saunders, Brown Instrument Co., "Pressure and Vacuum Gauges, and Recording Thermometers." Mr. Smith, Bristol Co., "Automatic Temperature Control." Mr. Cunningham, Republic Flow Meters Co., "CO_2 Recorders." Mr. Trueblood, Leeds and Northrup Co., "Advantages of Pyrometers." There was an excellent attendance at this meeting.

[1] Robert Boyd, *Secy.*

OBITUARY

M. E. Gregory

The death of M. E. Gregory occurred, May 3, 1926, at Corning, N. Y. Mr. Gregory was born at Caton, N. Y., July, 1864. He was a graduate of the Corning Free Academy and for several years taught school in New Jersey. In 1890 he entered into the terra cotta business and purchased this business in 1896. Until January 1, 1924, he manufactured paving brick, face brick and architectural terra cotta, and subsequently manufactured only terra cotta. Mr. Gregory had been a member of this SOCIETY for many years.

NOTES AND NEWS

CONGRESS OF AMERICAN INDUSTRY

The Congress of American Industry will be held in Philadelphia in September, 1926, lasting three weeks from Tuesday, Sept. 7, to Friday, Sept. 24.

The subjects for discussion will be: Sept. 7—9.30 a. m., "The Declaration of Independence," 2.00 p. m., "The Constitution of the U. S.;" Sept. 8—9.30 a. m., "Religious Liberty," 2.00 p. m., "Education"; Sept. 9—9.30 a. m., "Natural Resources," 2.00 p. m., "The Agriculturist"; Sept. 10—9.30 a. m.; "Research," 2.00 p. m., "The Chemist"; Sept.14—9.30 a. m., "The Engineer," 2.00 p. m., "Power and Its Distribution"; Sept. 15—9.30 a. m., "Illumination," 2.00 p. m., "Transportation"; Sept. 16—9.30 a. m., "Communication," 2.00 p. m., "The Financier"; Sept. 17—9.30 a. m., "The Distributor," 2.00 p.m., "The Publisher"; Sept. 21—9.30 a. m., "Industrial Associations," 2.00 p. m., "The Employee, His Responsibilities"; Sept. 22—9.30 a. m., "The Employer, His Responsibilities," 2.00 p. m., "Labor"; Sept. 23—9.30 a. m., "Industrial Management," 2.00 p. m., "Business Ethics"; Sept. 24—9.30 a. m., "Human Relationships," 2.00 p. m., "The Future."

There will be held in connection with the Congress, at its place of meeting, an exhibition of a habitat nature, portraying the habits, customs, and general conditions in a manner that will visualize the industrial advancement of the United States during the 150 years preceding 1926.

Purpose of Exhibit

The purpose of the exhibition is to portray the industrial progress of the United States during 150 years—1776 to 1926.

It is proposed to present the exhibition in fifteen distinct episodes, each episode illustrating a period of ten years, and introducing the various phases of industry as they become a part of the industrial life of the country. The exhibit will show in part the habits of the early settlers and industrial procedures which were so unlike those of today that it will make us more keenly appreciate the privileges and advantages that modern conditions offer.

It is believed that such an exhibition will arouse the latent pride of our American people to the advantages offered by our geographical location, natural resources, and form of government, and by means of comparison, impress especially the youth of today with a sense of appreciation of present privileges.

It is also believed that vocational pride will be the result of this exhibit.

Purpose of the Congress

The purpose of the Congress is to:

Hold a series of conferences.

Review and take an inventory of the industrial progress during the past 150 years.

Present papers on the fundamental subjects that will show the importance of individual efforts.

Better know public interest and bend our efforts in that direction.

Impart to the public knowledge of our benefits and of our progress.

Create better feeling between all factors in industry—that the relationship between employer and employee may be better understood.

Show that it is not necessary for one to possess the ability to complete an entire plan to be a success.

Show that success consists in doing creditably that part of work assigned to one.

Show the necessity of coördination to produce the finished product.

Abolish all idea of degrees and to prove that we all contribute to a given end, and that end is human progress.

Show that industry is the chief organ of advancement for civilization.

Show that the harbor to which civilization is headed is the enthronement of the spirit of man over the work of his hands.

Establish the relationship between the great principles and forces that are at work in the world.

Show that business is nothing more than personal service to the public.

Show that the day has gone by when any nation or any people or any individual can live or die unto himself.

Show the universality of human responsibility and human relations that will usher in the same kind of a new age in industry and the other relationships of life that the Constitution of the United States ushered in 150 years ago.

THE USE OF GEORGIA CLAYS

Georgia clays, properly mined, refined, and blended, can be utilized in the manufacture of chinaware, tiling, high-grade refractories, and ornamental face brick, and can be used to displace to some extent imported clays, according to the Bureau of Mines, Department of Commerce, which has finished a technical study of these clays, in coöperation with the Central of Georgia Railway. The State of Georgia contains large areas of sedimentary kaolins and bauxites of industrial importance. Considerable development has taken place, and many undeveloped deposits are available.

Georgia kaolins have heretofore been used to some extent in the several whiteware industries. They have been used in virtually every type of pottery body, both dry press and plastic, where a china clay is required. In some cases they have been used successfully, while in others their use has been discontinued because of various reasons more or less warranted. Their use has been abandoned by some chinaware manufacturers principally because of lack of uniformity. Many of the clays fire to a good white, while others fire to a cream color. Georgia clays have been used extensively in the sanitary tile and electrical porcelain industries, but some manufacturers of these wares have not made use of them because black specks developed during the firing.

The Bureau of Mines investigators found that, by the use of proper washing methods, the Georgia clays can be washed free from material that causes dark specks in whiteware. It was found that many clays which fired to an undesirable cream color could be produced white enough to meet requirements if the proper care were taken in their mining and refining. A serious problem in connection with the use of sedimentary clays in white ware is the high bisque loss and excessive shrinkage. These difficulties can, the Bureau found, be largely overcome by proper body mixes and by the blending of the clays.

Georgia contains large deposits of refractory clays suitable for the manufacture of high-grade refractories. If enough of the clay is fired to a high temperature and used as a grog, the brick will go through the process of manufacture readily and will withstand

every laboratory test for a high-grade refractory. Furnace tests under actual working conditions have proved that the service rendered by fire brick made from Georgia sedimentary kaolins was at least equal to and in most tests superior to that rendered by fireclay and aluminous brick.

These findings are of real industrial importance in view of the fact that supplies of the best fire clays of Pennsylvania, Maryland, Ohio, and Kentucky within reach of the railroads are decreasing, and the average quality of the fireclay refractories classed as No. 1 has fallen off within the last 15 to 20 years. It must, of course, be recognized that there are fireclay refractories on the market at the present time as good as any in the past, but the bulk of such, as a class, has evidently decreased in refractoriness.

Light-cream and light-gray face brick can be made from a mixture of Georgia kaolin, aplite, and sand, and these brick compare favorably with the best face brick from the fire clays of the Freeport, Mercer, and Kittanning formations of Pennsylvania. This is of importance as, throughout the southeast, and more especially in the coastal plain States, no clays have been found from which face brick, light cream to clear buff and light gray in color, can be made. Large quantities of such brick are used in this territory for building purposes and substantially all are shipped in from north of the Ohio and Potomac Rivers. These desirable light-colored brick carry a freight charge of $18 to $20 per 1,000, which makes their delivery cost up to about $48 to $50 per 1,000.

Details of this investigation are contained in Bureau of Mines Bulletin 252, "Beneficiation and Utilization of Georgia Clays," by R. T. Stull and G. A. Bole, copies of which may be obtained from the Superintendent of Documents, Washington, D. C., at a price of 20 cents.

SOCIETY OF GLASS TECHNOLOGY

The ninth annual general meeting of the Society of Glass Technology was held in Sheffield on April 21. Walter Butterworth succeeded T. C. Moorshead as President. The other officers elected to fill vacancies were: Vice Presidents F. F. S. Bryson and S. English. Ordinary Members of Council: R. S. Biram, E. A. Coad-Pryor, A. Cousen, W. J. Gardner, and C. J. Peddle. Joseph Connolly was reëlected general treasurer, F. C. Flint was appointed American treasurer, and W. E. S. Turner was reëlected honorary secretary.

The Annual Report for 1925 showed 237 members who were resident outside the United Kingdom, and these members were drawn from nineteen different countries.

At the ordinary meeting which followed, four papers were presented as follows:

(1) "Notes on the Devitrification of a Lead Borate Glass," by C. J. Smithells. Specimens of tungsten filaments were prepared for microscopic examination by embedding them in a fused lead borate glass, held in a brass cup, and subsequently grinding to the required section after the glass had solidified. After the specimen had been polished it was usually etched with alkaline potassium ferricyanide solution for about 15 seconds. An examination of a number of specimens prepared during the last five years showed that in certain cases a number of crystals were visible in the glass when viewed under the microscope with vertical illumination. Further investigation showed that the crystals were not visible in the polished specimens, but only after etching. It was found that the specimens could be divided roughly into groups, showing various degrees of devitrification according to the age of the specimen. The observations appeared to illustrate a simple case of slow crystallization at room temperature, and indicated the possibility of detecting devitrification in other glasses by means of a suitable etching reagent.

(2) "A Note on Some Factors Governing the Resistance of Pots to Glass Attack," by J. F. Hyslop. It had been noted that one series of pots–K1–gave exceptionally long

life, and even when removed from the furnace these pots showed no evidence of excessive wear. Another series of pots–K2–had a satisfactory life, but they showed convincing signs of severe attack. In both cases a standard alkali-lead oxide glass had been used. In order to study the constitution of the pots, small sections were ground and polished, and on exposure of a beam of X-rays, each crystalline phase in the material gave its own precise diffraction pattern. By finding the patterns for known compounds it was comparatively easy to identify the constituents present in the material. The results obtained showed that the matrix was a more potent factor than the grog in determining the rate of attack of a pot. In order to form a highly desirable protective layer it was necessary to have a high alumina content in the clay. If the fired clay had a high percentage of mullite it would tend to form with the glass in intermediate layer of high viscosity. In the case of a composite refractory such as a pot, the evidence strongly suggested that a high mullite content was essential in the matrix of the body.

(3) "The Behavior of Sillimanite in Tank Furnaces," by E. A. Coad-Pryor. Comparative tests were made of sillimanite blocks of standard size (24 x 18 x 8 inches) made by two separate firms. The blocks were built into a tank furnace on the flux line, between the filing on end and the bridge. The tank was run for 24 weeks on an ordinary flint glass, twenty tons of glass being drawn daily. The blocks were carefully removed and examined. It was then found that the sillimanite had been corroded more severely than the fireclay blocks alongside. In the discussion that followed, W. J. Rees pointed out that with recent well-made sillimanite blocks much better results could be obtained than those indicated in the paper.

(4) "The Detection of Small Amounts of Selenium in Glass," by J. D. Cauwood and E. J. C. Bowmaker. The authors examined Dragendorff's qualitative test for selenious acid and applied it as a basis for detecting the presence of selenium in glass.

Another paper was taken as read, owing to lack of time, namely, "Note on the Purification of Sand," by J. T. Howarth and W. E. S. Turner.

EYE-SIGHT CONSERVATION

Production is the all inclusive word in industry. It matters not whether it be industry of the hand or of the brain, the ultimate aim is to produce something which will be of value to somebody for some special purpose. This production, no matter of what type, is particularly concerned with two important factors—quality and quantity. And these two factors depend not only upon the efficiency of the machinery used in turning out the product, but also upon the efficiency of the human element.

No less than 8000 separate and distinct occupations are open to the workers of the United States. Efficiency calls not only for the protection of the worker's eyes against the hazard of his job, but also the protection of the job against the economic hazard of poor eyesight which results in ruined work materials, low production, accident frequency and high absentee rates.

The three requisites of eyesight efficiency in industry are namely:—eyesight examination, goggles supplied and the wearing of them insisted upon for all work with eye hazards, and proper illumination.

First—eye examination. The most delicate, yet the hardest worked of all the organs are the eyes. They are sensitive spots of brain tissue and any irritation to them means irritation to the brain and through it to the entire nervous system. Safety often depends upon normal vision. This is reason enough for routine practice of testing the sight of all applicants for employment, not to bar men from industry, but to make better workmen of them because their eye defects have been detected and remedied.

Probably no organs are more abused than the eyes. The loss of vision is usually so gradual and unaccompanied with pain that no danger signals are noticed by the victim. Many employees need aids to vision and do not know it. Some have become accustomed to the inability to see distant objects plainly. Others have unknowingly allowed their eyes to become strained.

Second, goggles supplied and worn. For all work where there are eye hazards, goggles should be insisted upon. It should be realized that eye hazards surpass all other industrial hazards in severity. Yet the workman who needs eye protection most is often the one who complains against wearing the goggles supplied him.

No eye injury is too trivial for skilled attention. The delicate structure of the eye is most susceptible to injury because its work leaves it, to a large extent, exposed. The function of the eye does not permit of a circulation of blood in the cornea and therefore the danger of infection from any injury, however slight, is inestimable.

Accidents cause a drop in the morale of all nearby workmen, aside from the suffering of the injured one. The employer must stand the monetary loss not merely of the entirely suspended production of the injured one, but also the decrease in production due to the lowered morale of his working force.

Third—proper illumination. It is fair to assume that the employer who manifests an interest in the employee to the extent of having the employee's eyes examined will also see to it that his workrooms are adequately lighted. Eye fatigue may be brought on by insufficient illumination or by too glaring light. Glare always means a constant adjustment of the eyes in order to see.

Dr. George M. Price, of the Board of Sanitary Control, has been credited with stating that it has been the experience in manufacturing plants equipped with scientific systems of illumination that the following benefits are secured: 10% more output, 26% fewer accidents, 25% less spoilage, 25% better workmanship.

The Eye Sight Conservation Council of America, with headquarters in the Times Building, Broadway and 42nd Street, New York City, is ready at all times to coöperate by voluntary information with anyone desiring to promote the conservation of eye sight in the home, the school, or industry.

CALENDAR OF CONVENTIONS

AMERICAN CERAMIC SOCIETY		
Summer Meeting	To be announced later	Philadelphia, Pa.
Annual Meeting	Feb. 14–19, 1927	Detroit, Mich.
Amer. Foundrymen's Ass'n	Sept. 27, 1926	Detroit, Mich.
Amer. Gas Ass'n	Oct. 11–14, 1926	Atlantic City, N. J.
Amer. Inst. Chem. Engrs.	June 21–23, 1926	Berlin, N. H.
Amer. Mining Congress	December, 1926	Washington, D. C.
Amer. Soc. Mech. Engrs.	Dec. 6–9, 1926	New York City
Amer. Soc. Testing Materials	June 21–26, 1926	Atlantic City, N. J.
Ass'n Iron and Steel Mfrs.	May 31–June 5, 1926	Chicago, Ill.
Congress of American Industry	Sept. 7–24	Philadelphia, Pa.
Manufacturing Chemists' Ass'n	June, 1926	Near New York City
Natl. Ass'n of Mfrs.	Oct. 20–22, 1926	New York City
Natl. Safety Council	Oct. 4–9, 1926	Detroit, Mich.
N. J. Clayworkers' Ass'n	June, 1926	Trenton, N. J.
Ohio Ceramic Industries Ass'n	Oct. 1926	Columbus, Ohio

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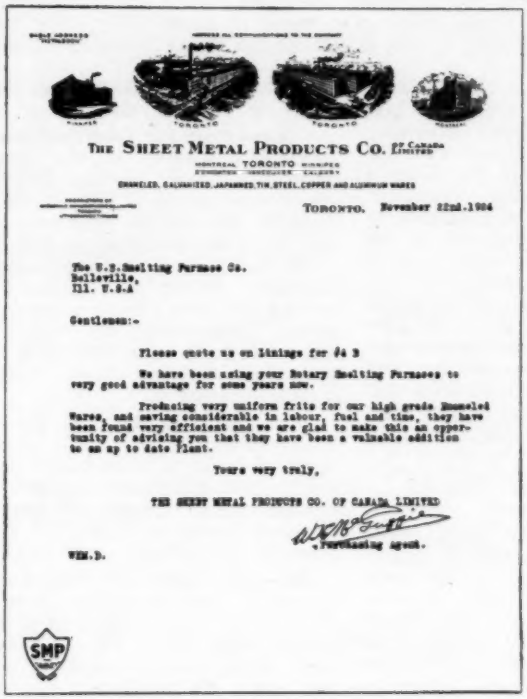

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THESE twelve states—North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, Tennessee, Arkansas, Virginia and Kentucky—constitute the South's 5 million dollar Electrical Porcelain Product Market. The manufacture of Electrical Porcelain Products in the South is negligible. Splendid opportunities await the manufacturer who establishes a branch plant in the South to serve the South. The unusual economic advantages, of considerable saving in raw material assemblage and distribution costs, are two features that alone justify investigation of your possibilities in the South for Electrical Porcelain manufacture.

Less Cost for Raw Material Assemblage—

Every raw material for high grade Electrical Porcelain Products manufacture is available in the Southern States, Georgia in particular. A comparison of raw material assemblage costs to a location in Georgia as against two of the most notable ceramic centers of the North, follows—Ball Clay, from Tennessee and Kentucky to North $8.89 and $5.29 per ton—only $2.82 to Georgia. Feldspar from North Carolina to North $5.40 and $4.80 per ton—only $2.82 to Georgia. Kaolin or China Clay from Florida to North $7.81 and $9.49 per ton—only $4.43 to Georgia. Kaolin or China Clay from Georgia to North $6.01 and $7.09 per ton—only $1.00 from Georgia mines to Atlanta, Ga.

Less Cost for Distribution—

Obviously, located in the South to serve the South, besides enjoying a lower raw material assemblage cost there is the decided economic advantage of lower distribution cost to any of the Southern States, from any of the Southern States, as compared with serving the South from a northern location. Distribution costs from a central point in Georgia to 12 large representative Southern cities, is approximately 40% lower.

Low Building Material Costs—

The following figures are the average costs of building materials in Georgia—Common building brick, $11 to $14 per thousand. Cement $3 per barrel. Crushed Stone $1.25 to $1.65 per ton. Lumber $24 to $60 per thousand feet.

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Common labor costs run from 20 to 40 cents per hour. Fuel oil at present ranges from 6½ to 7¼ cents per gallon. Coal costs from $3.50 to $4.50 per ton. Hydro-electric power lines cover the western, middle and northern sections of Georgia.

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B

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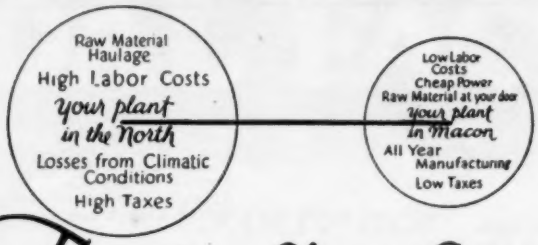

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Seaboard Fuel Corp.

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D

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Proctor and Schwartz, Inc.

Dryers (Steam Pipe Rack)
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Drying Machinery
Philadelphia Drying Machinery Co.
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Dust Mills
Cain Machine Co.

E

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Mueller Machine Co., Inc.

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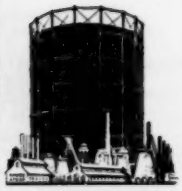
Chicago Vitreous Enamel Product Co.
The Porcelain Enamel & Mfg. Co.



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F

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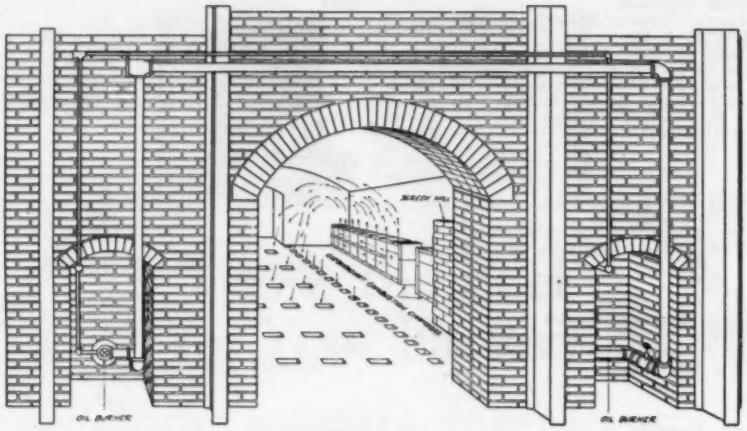

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K

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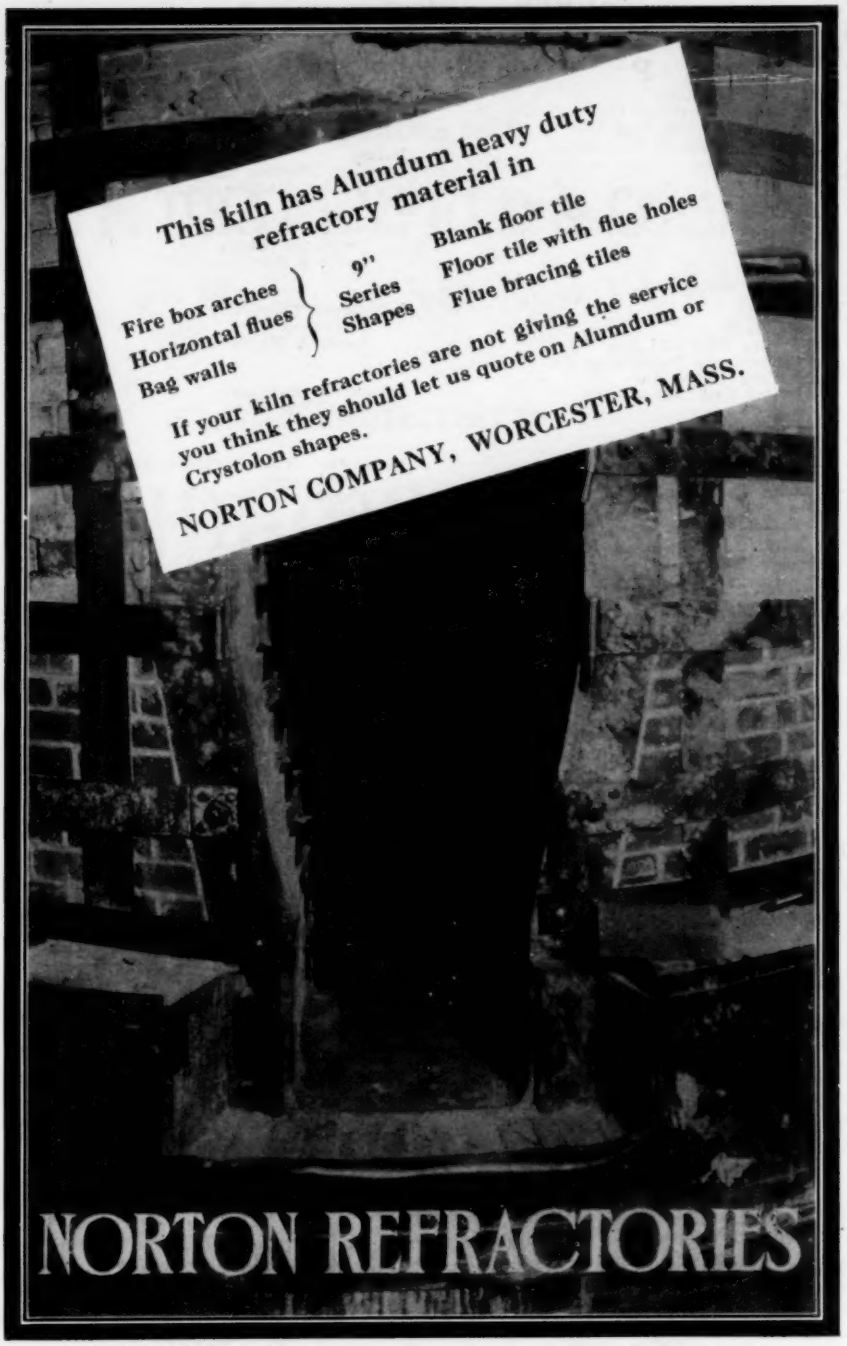
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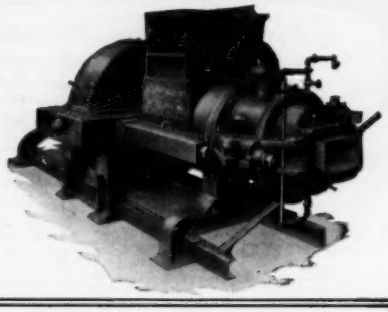

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Two Ways to Line a Mill

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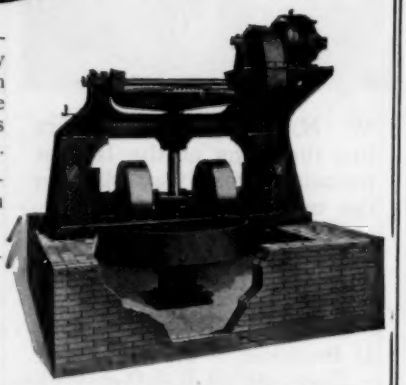

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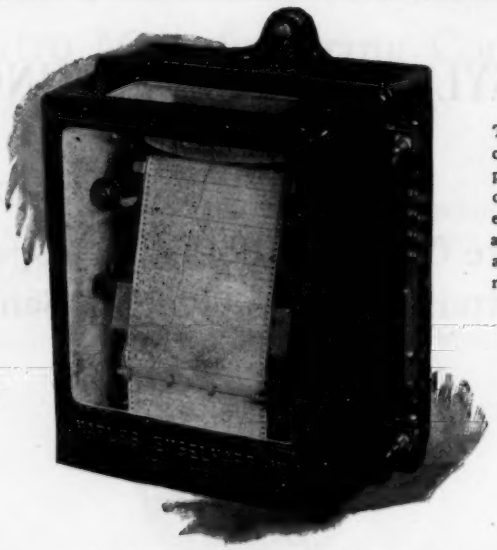

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99.97% Pure Silica — 140 Silk Lawn Test

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The Purest Iron Made

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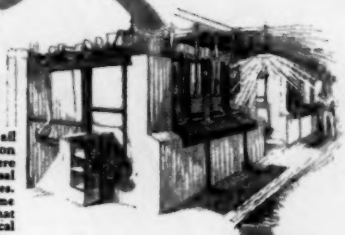

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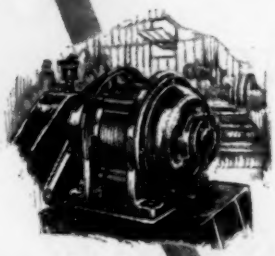
Electric drive cleared industry of its expensive and dangerous jungle of shafts and belts, brought great flexibility of operation, and speeded manufacture to a high pitch. Such were the economies effected that the cost of the old drives scrapped and the new motors installed, never entered the picture.



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And for Its Heat

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Annealing glass in electrically heated lehrs. The latest development in the glass industry!

Where 4 to 10 hours were required, the glass is now annealed in one hour and thirty-five minutes.

Where before, rejections were common, there is now a total absence of expensive breakage.

The cost of operation of electric lehrs is no greater than that of other lehrs.

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The annealed products are so uniformly high in quality that customers are demanding electrically annealed glass.

Several large companies have obtained these results and already one of them is annealing its entire output of glass in electrically heated lehrs. The glass at red heat is carried on conveyors through a heating zone, equipped with G-E heating units and G-E automatic control, to equalize its temperature, and then into a lower temperature zone, similarly equipped for gradual cooling.

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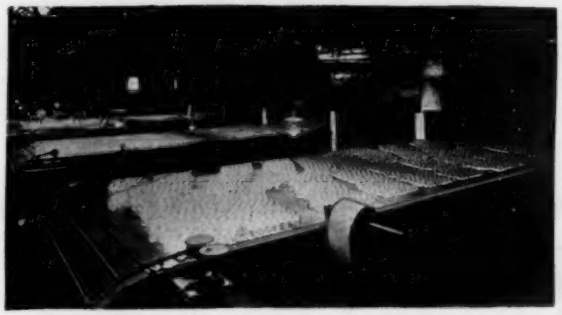

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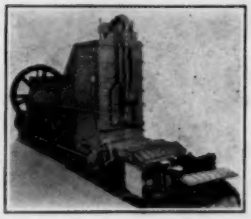
Fire Brick Facts



Day by day fire brick requirements and specifications are becoming more rigid. Purchasers are making tests before buying, with greater severity than ever—due to more exacting refractory uses.

Many brick manufacturers are making fire brick on the AutoBrik Machine at production costs that are, in some cases, lower by $2.70 per thousand. These brick need no repressing and are unsurpassed in quality.

The AutoBrik Machine—with its fully automatic features and high-speed production—can save money for you. Ask Lancaster Engineers to send you new Bulletins No. 10 and 10-A describing this time and labor-saving machine.

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BRICK MACHINERY DEPARTMENT JAMES P. MARTIN, Manager

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Cleveland, Ohio

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On Engineer's Day at one of our leading universities, the various colleges entered floats in a parade, each one depicting their particular line of endeavor. On checking over these floats we found the following various items made by ceramic engineers upon which the particular profession was dependent.

Chemical Engineering, glassware.

Metallurgical Engineering, refractories.

Electrical Engineering, porcelains.

Architectural Engineering, ceramic wares of various shapes, sizes and colors.

Mechanical Engineering, abrasives, porcelains, etc.

Mine Engineering, optical glass, electrical insulating porcelains, etc.

Civil Engineering, optical glass for transits, etc.

The above are only a few items produced by our ceramic engineers for use in the other branches of engineering. What would be the result on progress of the engineering profession as a whole if it could not obtain ceramic products with which to work? Can you blame us for being proud of our profession?

Suppose the Journal of the American Ceramic Society did not exist—where would American ceramic technical literature be found? Outside of personal contact, where would you obtain an advertising medium to even begin to compare with Journal? Our space is limited but we hope the few statements above will start you in the right way for your ceramic advertising campaign.

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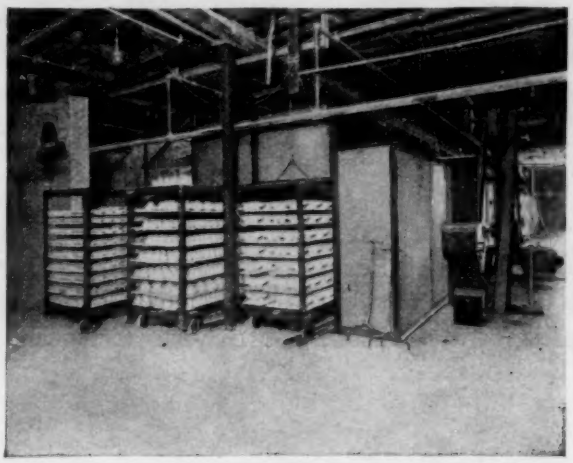

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